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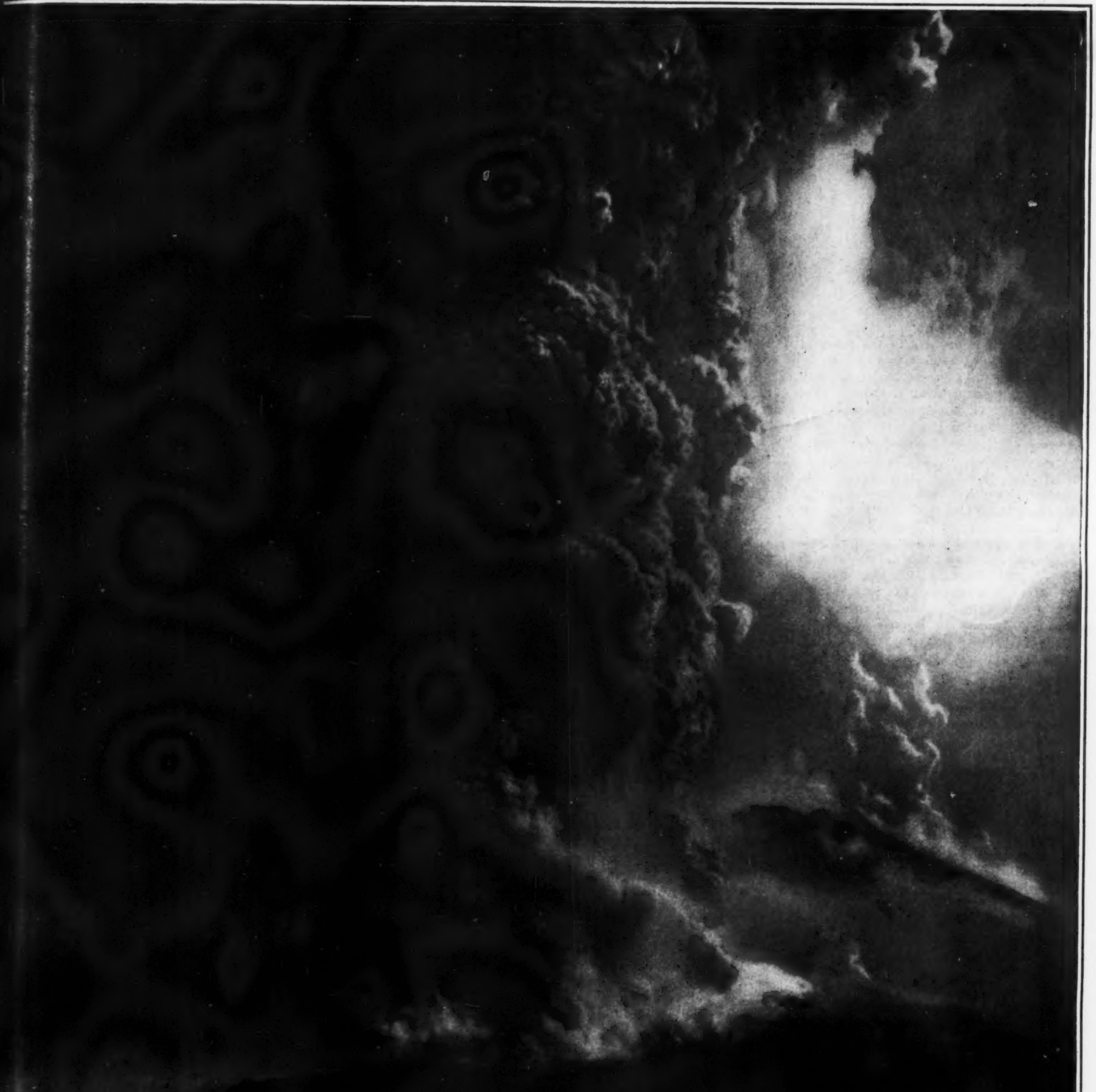


REMARKABLE PHOTOGRAPH TAKEN OF THE VOLCANO ON SAKURAJIMA ISLAND, JAPAN, DURING ERUPTION.—[See page 242.]

The Sakurajima Eruptions and Earthquakes*

Abstract of a Memoir by Prof. E. Omori

SAKURAJIMA (Cherry Island), situated in Kagoshima Bay, and famous for its eruptions in 1779 and in several earlier years, was the seat of an outburst in January, 1914, which may be counted, in point of the magnitude of disturbance, as one of the greatest volcanic catastrophes of modern times. Many scientific men, Japanese and foreign, hastened to the scene of the outbreak; among them the writer of the present memoir, who, sent as a member of the Imperial Earthquake Investigation Committee, remained in the stricken district from the 16th to the 26th of January, and made a second visit in April. The following paragraphs give a short preliminary account, from the seismological point of view, of the Sakurajima eruption, the occurrence of which indicated the existence of a clear sequence among the various recent manifestations of volcanic activity in Japan.

Topography.—The island is irregularly elliptical, the greatest diameter in any direction being 11.4 kilometers. Near the center of the island there are two high peaks, the Minamidake ("south crater") and the Kitadake ("north crater"), respectively 1,069.6 and 1,133.5 meters in height. Together with a slightly depressed intermediate portion they form a ridge 1.8 kilometers in length running nearly in a north-south direction. Thus from the east or west the island looks like a truncated triangle and presents a beautiful Fuji type of outline with a flat top, while from the north or south it appears in the form of a pointed cone. There are several minor craters, lava promontories, and, in the adjacent bay, volcanic isles formed in connection with past eruptions. There are hot springs at several points on the southeast coast, and a mineral spring in the shallow sea water close to the beach of Saido on the northwest coast. The island had a population of 23,738, distributed in twenty hamlets.

Sea Depth and Mountain Size.—Sakurajima is a small volcano rising out of a shallow sea, the total volume of the island above the water level being 26.5 cubic kilometers, which will not be much augmented by adding the portion below the sea. Its magnitude is about equal to that of Ususan, but only about one eleventh that of Asamayama (i. e., the part of the latter above the plateau on which it stands), and about one fortieth that of Fujiyama. Its small size coupled with great activity probably means that the lava reservoir is at the slight depth of only a few kilometers, and that the frame of the mountain is comparatively weak for resisting an internal explosive condition; hence the unmistakable premonitory signs in the form of numerous earthquakes for several hours preceding the recent eruption, as well as that of 1779. Again, the eruptions were intense and of long duration, throwing out a great quantity of fluid lava, pumice and ashes, but the individual explosions were not quite so powerful as those of Asamayama.

Simultaneous or Successive Activity of the Different Volcanoes.—The four main Japanese islands, which form a simple arc with steep descent on the convex side into the deep basin of the Pacific, may be regarded as a volcanic chain or earthquake zone which is still undergoing stress accumulation. When the later reaches its limit, telluric disturbances may occur one after the other in various parts of the country in the form of great earthquakes or volcanic outbursts, as the case may be. The epoch of most violent eruptions in the history of Japan was an interval of fourteen and one half years between 1777 and 1792. There was first an eruption of Oshima, lasting, with intermissions, from August 22nd, 1777, to December 18th, 1778, with an enormous outpour of lava; then occurred the great eruption of Sakurajima on November 8th, 1779, with remarkable lava outflows and the formation of new islands; then Aogashima, one of the Izu Islands, was in eruption from July 28th, 1780, to April 18th, 1785. Meanwhile, on May 9th, 1783, Asamayama broke out in strong eruptions, which terminated in a terrible downrush of "volcanic avalanches" on August 5th. Finally, the eruption of Unsendake, in Kyushu, began February 12th, and terminated May 1st, 1792, in a tremendous catastrophe, when the whole Southern slope of Maeyama was precipitated into the sea, causing great waves (*tsunami*) which cost 15,000 lives.

It will be noted that of the five volcanoes mentioned, two are in Kyushu, while the other three belong to the Fuji volcanic chain. In spite of the wide distance between the two groups the different volcanoes were thrown into great activity one after the other, and this was also true of the most recent series of eruptions.

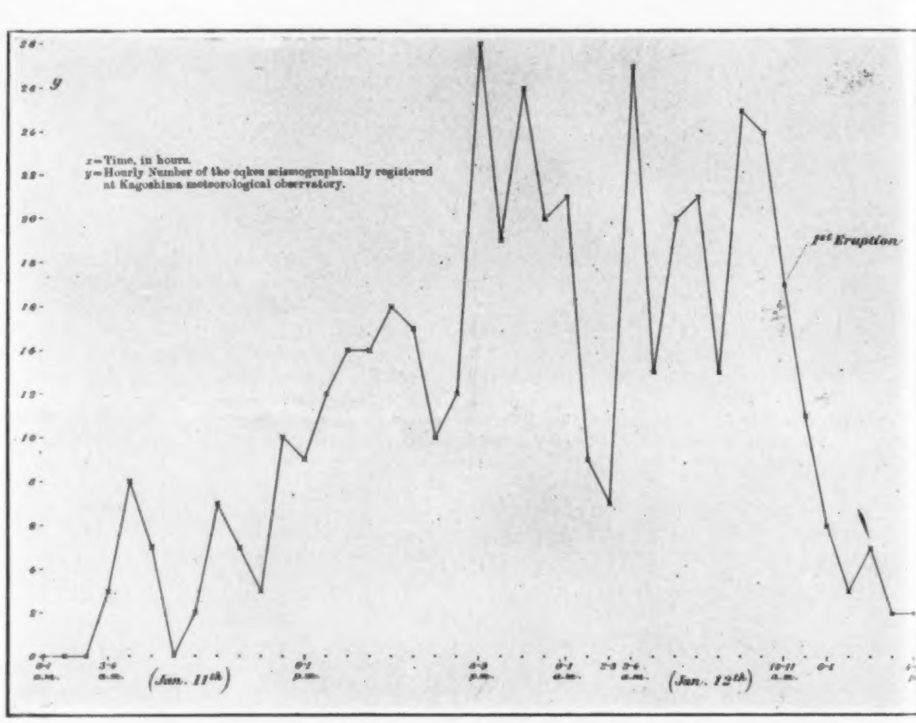
Recent Activity and the Sakurajima Eruptions.—An examination of the time distribution of the outbreaks of Asamayama indicates a recurrence of the epochs of greatest eruptive frequency with a mean interval of about 63½ years. Hence, twice this interval, viz., 127, or, say, 130 years, may also be regarded as a possible period in the frequency of eruptions, and it is noteworthy that Asamayama, Oshima, and Sakurajima, which had had no great outbreaks since the epoch of the eighteenth century just mentioned, have again exhibited, after a lapse of 130 years, a period of extraordinary activity.

In December, 1907, a period of eruption in the Fuji chain began with outbreaks of Yakedake, which were followed by a series of violent earthquakes and eruptions from Asamayama, beginning in 1908. In 1912 magnificent lava outbursts occurred from Oshima in March-April, and again in September-October. The explosions of Yakedake reached their climax in the summer of 1911, and ceased in the summer of 1912; the eruptions of Oshima ceased in the spring of 1913, and Asamayama apparently approached the final stage of its recent activity about the same time. The recent eruptive energy of the Fuji chain thus drawing to a close, the Kyushu volcanoes were expected, in view of their past history, to have their turn of activity. From May 19th, 1913, frequent small earthquakes began to be felt in the region at the northern and western bases of Kirishimayama, which had been quite for 10 years. This sudden appearance of seismic disturbances was at once interpreted as foreboding eruptions in Kyushu, and as early as June, 1913, the present writer urged the governor of the Kagoshima-ken to set up a sensitive seismograph at the Kagoshima meteorological observatory. Meanwhile the seismic disturbances extended to the peninsular part of Satsuma, and at the end of June a strong earthquake occurred some 16 kilometers west-northwest of the city of Kagoshima. On November 8th Kirishimayama broke into strong eruption; another violent outburst occurred December 9th; and a third January 8th, 1914. On the morning of the 12th the author received a telegram stating that 337 earthquake shocks had occurred in the city of Kagoshima between 3 A. M. of the 11th and 6 A. M. of the 12th. The author was about to telegraph instructions to Kagoshima urging that a careful watch be kept of Sakurajima, which could be the only cause of these unusual seismic phenomena, when press dispatches arrived announcing that the volcano had broken into eruption.

Premonitory Signs.—Unlike large destructive earthquakes, which originate along seismic zones, but are not repeated from one and the same center, the eruptions of a given volcano, whether occurring from the central crater or from new side vents, are at least localized in the mountain itself. Hence it may be that the great eruptions from a given volcano at widely different epochs resemble one another more or less, both in the eruptive phenomena and in the precursory events. Thus the sequence of phenomena in and preceding the Sakurajima eruption of 1779 was almost exactly duplicated by the events of the recent eruption, which will now be sketched briefly.

The accompanying diagram (Fig. 3) shows the hourly frequency of the earthquakes registered at the Kagoshima observatory, 10 kilometers distant from the center of Sakurajima, with an ordinary Gray-Milne-Ewing seismograph. The shocks were much more frequent and were felt some hours earlier, on the island itself.

The hot springs, ordinary springs, and wells of the island were much disturbed on the 12th. White smoke was seen at certain places over the mountain as early as the afternoon of the 11th, and at 8 A. M. of the 12th a column of white smoke was suddenly shot up in the form of a pine tree from the south crater. In view of these unmistakable warnings, a general exodus of the inhabitants of the island began on the 11th. The prefectural authorities took prompt measures to aid the escape, and the result was that the entire population of more than 23,000 was brought safely out of danger, with the exception of two clerks of the village office of Higashi Sakurajima, who heroically remained until the eruptions had begun and were drowned in attempting to swim to the mainland.[1]



Hourly frequency variation of the earthquakes which preceded the Sakurajima eruption of January 12th, 1914.

Eruptions.—The first outburst took place from the west side of Sakurajima about 10 A. M. of the 12th from a point about 500 meters above sea-level, followed about 10 minutes later by an outburst on the southeast side. Red fire was seen from Kagoshima at the base of the smoke column 5 minutes after the eruption began; lava blocks were seen to be thrown out abundantly from 11:30 A. M.; and explosive detonations began to be heard at 3:30 P. M. The dense black smoke which, the weather being calm, was finally projected to a height of 20,000 feet above sea-level, was traversed by lightning in various directions. Panic reigned in the neighboring city of Kagoshima, where wild reports were spread as to the poisonous effects of the volcanic gases, and apprehensions were also felt of *tsunami* (tidal waves); hence the majority of the inhabitants fled to the country. The explosive stage of the volcano reached its full intensity between about 11 P. M. of the 12th and 5 A. M. of the 13th, with a maximum

* From the *Bulletin* of the Imperial Earthquake Investigation Committee, Tokyo.

[1] Compare newspaper reports, which, even some weeks after the eruption, estimated the loss of life on the island at 200, in addition to the persons who actually were killed by earthquakes in Kagoshima.—EDITOR.

about 1 A. M. The detonations at this stage were so loud that the prefectural officers in Kagoshima had to stuff their ears with cotton. The eruptions on the west side of the island virtually ended January 25th, but those on the east have kept up their energy and are still (August, 1914) making occasional strong outbursts.

About seven principal craterlets were formed on the west and eight on the east side of the island; none higher than 500 meters. The lava which flowed from these was of very little fluidity, so that it is generally broken up into loose angular blocks. The main lava stream on the west side flowed down during the first two days at the rate of 45 meters an hour. On the east side the lava had, by the 29th, completely blocked up the strait separating the island from the mainland, thus converting Sakurajima into a peninsula. The eastern lava field ultimately attained an area of 15.41 square kilometers, of which 7.97 square kilometers is under water; the western field has an area of 8.33 square kilometers. The thickness of the lava is from 40 to 100 meters, and the total volume ejected is estimated at about 1.6 cubic kilometers, or about one seventeenth the volume of the mountain.

The precipitation of pumice and ashes was very abundant in the eastern part of the island, being deepest near Kurokami, where it amounted to 6 feet or more and buried the houses nearly up to the roofs. Ashes, carried by the westerly winds, fell in the Bonin Islands to the southeast, and northeast over most of Japan west of Mito and Utsunomiya, the extreme eastward radial distance being over 1,200 kilometers. The total volume of ashes and pumice is estimated at 0.62 cubic kilometer. This amount, added to the above estimated output of lava, gives a total equal to *one twelfth the volume of the mountain.*

Strong Earthquakes and Small Tsunami.—The strong earthquake which occurred at 6:30 P. M. on the 12th, and which cost 19 lives in Kagoshima, was recorded in Tokyo, and must have been of several times greater magnitude than certain earthquakes attending recent eruptions of Asamayama and Ususan, which had been supposed to represent the limiting intensity and size of a volcanic earthquake. It was probably, however, of very deep origin, and the result rather of the stress accumulation along the whole volcanic chain in southern Kyushu than of the Sakurajima eruption alone. An hour or more after this shock a slight inundation occurred along the harbor front of Kagoshima (at high tide). The direct cause of this *tsunami* was, however, probably a small, sudden settlement or depression of the bottom of the bay.

Tromometer Observations of the Eruptions.—A tromometer in operation at Kagoshima beginning with the 16th recorded the tremors due to the successive eruptions, and showed, among other things, that the explosions with loud detonation produced very slight seismic effects as compared with non-detonative eruptions. It is likely that the latter are much more important phenomena, and consist in the powerful projection of ashes and gases along pre-existing channels of deep extension.

Effects on Water Level; Depression of Coast.—The results of leveling by the Military Survey Department compared with heights determined in 1892 indicate that there has been a depression of the coast amounting to about 0.2 meter at Kagoshima, and reaching 0.67 meter at a small promontory about 10 kilometers northward along the coast. The greater part of the depression thus found may possibly be the result or precursor of the recent eruptions.

Arrangement of Craterlets.—The new craterlets extend in a zone running from west-northwest to east-southeast; i. e., at right angles to the axis of the volcanic chain of which Sakurajima forms a part. Hence the new vents pertain to a system of secondary fracture limited to the island itself. The formation of craterlets on two opposite flanks of the mountain, which also occurred in 1779 and 1476, indicates that it is easier for the eruptive energy of Sakurajima to find vents near the base of the mountain than to push up the internal lava to its top.

Activity Along the South Kyushu Volcanic Chain.—As already stated, the strong explosion of Kirishimayama, on January 8th, 1914, was followed quickly by the great Sakurajima eruption of January 12th. Then Iwojima, situated off the south coast of Satsuma, was the seat of an eruption February 13th, accompanied by several earthquakes, one of these being of fairly large magnitude. Finally, Suwanosejima, still further southward, had an eruption on March 21st. These four volcanoes are in nearly a straight line.

These eruptions have probably brought the volcanic activity in this part of Kyushu to an end for the time being, and the site of volcanic outbursts appears to have again shifted to the Fuji volcanic zone, where Oshima, after a quiescence of about a year and a half, gave rise to very powerful lava eruptions for about seven days in May, 1914.

Gasoline Locomotives

By A. H. Ehle

GASOLINE locomotives for surface work have been in successful use for some six years and are mainly distinctive because of combining certain well-established steam locomotive principles with a source of motive power that has become highly developed through the introduction of automobiles. It is apparent that in a gasoline locomotive the object sought is to produce the maximum tractive effort or drawbar pull, the locomotive itself seldom being required to carry a load as in the case of automobile trucks. Because of the different conditions under which a locomotive must operate there is something more required than the mere incorporation of good automobile practice.

Gasoline locomotives have been particularly successful in work around contracting operations, plantations, quarries, smelting plants—in fact for almost all industrial purposes where loads are to be hauled at moderate speeds and within the range of available motor powers that can be placed within the gage limitations imposed. Obviously they are safe and unlike some other forms of locomotives independent of power sources external to themselves. However, notwithstanding their convenience and serviceability their more general introduction depends upon the economic consideration of first cost and fuel-operating expense compared to other available kinds of locomotives.

At present the Baldwin Locomotive Works are making four sizes of narrow-gage industrial machines weighing 3½, 5, 7, and 9 tons, having drawbar pulls on high gear, on level track, of 750, 900, 1,300 and 1,700 pounds, respectively.

The locomotives are provided with two-speed transmission giving general speeds of 4 and 8 or 5 and 10 miles per hour in either direction. In addition to these sizes there has lately been developed a considerably larger or 18-ton machine built for standard gage only and having a three-speed transmission providing speeds of 6, 12, and 20 miles per hour in either direction. Its guaranteed drawpull on low gear is 6,000 pounds, on middle gear 3,000 pounds, and on high gear 1,700 pounds.

An 18-ton machine, as above described, on test exceeded the specified drawbar pull or hauling capacity by about 50 per cent when operating on either gasoline or kerosene. It was designed for industrial switching service and to haul a total of about 200 tons on level track around 28-degree curves, or the equivalent of lighter loads up various grades. The consumption of either gasoline or kerosene was found to be in average service about 4¼ gallons per hour, hauling about 80 tons total back and forth over a track having level stretches and grades as high as 3 per cent. This particular fuel test was conducted for two hours, the locomotive pausing only long enough to reverse its direction at the ends of the runs. The loads were hauled on the low gear speed of 6 miles per hour. This locomotive has hauled a total of 234 tons up at 1½ per cent grade and around 25-degree curves at a speed of about 5 miles per hour.

The motors are all water-cooled and of the four-cycle four-cylinder vertical type, especially designed to withstand severe service. There is nothing radical about them; they conform quite generally to the larger motors used in automobile construction. They are almost invariably equipped with electric motor starters, after the manner usual in automobile practice. The ignition is by battery and automatic spark advance magneto.

The gears, shafts, clutches, and all other transmission parts are of very liberal proportions, since there is not the necessity of keeping down weight as in the case of automobile design. The running parts are inclosed in an oil-tight cast iron housing which constitutes a separate unit. In this way lubrication is easily provided for and the parts are permanently held in rigid alignment.

The main clutch is of the multiple-disk type, the purpose of which is the same as in automobile work. The alternate bronze and steel disks run in a bath of oil and the combined surface is extremely large for the horse-power transmitted. The clutch can be slipped almost continuously without excessive heating or perceptible wear.

The main frames are of the cast steel bar type and generally similar to those used in steam locomotive practice. They are naturally stronger than cast iron frames of equal weight, and because of their design the motor and running gear are more accessible.

The side- or driving-rods are of hammered steel with solid ends. A wedge adjustment is provided at the jack-shaft and a plain bronze bushing inserted by hydraulic pressure at the other end. The solid driving pin brasses in the yokes are free to move vertically without bringing any strain upon the rods.

An efficient interlocking hand- or foot-operated brake is provided with shoes on all the wheels. These shoes are of the M. C. B. type and detachable from the brake-heads, where desired air brakes also can be applied.

The radiator is substantially constructed with unusually large surface and water capacity. In appearance it is very much the same as those used on large automobile trucks. It is of such proportions as to prevent over-heating when developing full power under the most severe hauling conditions. Air circulation is maintained by a fan driven from the engine flywheel.

What are the prospects of expanding this type of locomotive into large sizes to take care of passenger and freight work now handled almost exclusively by steam locomotives? They are promising, but even after successfully solving such problems as sufficient power, available space, method of power transmission, etc., it must be clearly demonstrated that from an economic standpoint internal combustion locomotives can hold their own with the well established steam and electric types.

In the light of present experience and knowledge, however, it seems more probable that permanent results will be obtained by working in other directions. For instance, there are attractive possibilities in the use of a locomotive employing compressed air as the working medium. In such a machine the gas engine would be direct-connected to an air compressor delivering air to a suitable reservoir, the air from this reservoir being utilized in cylinders and with mechanism very similar to those of steam locomotives of the present time.

It may be that for internal combustion locomotives the prime mover itself will be used for quite a different purpose. Instead of endeavoring to produce the maximum amount of rotative effort at the engine crankshaft, the transmission difficulty may be obviated and the efficiency raised by producing directly from the fuel the maximum amount of exploded gas under pressure, which latter will then be conveyed to operating cylinders as in the case where compressed air is the working medium. The mechanism for producing this exploded charge may possibly follow present design with respect to the essential parts of the machine, but with such parts obviously intended for different purposes. At first thought it might appear quite impracticable to retain the heat and thus the energy so produced, but thus far it is not known what can be done by exploding a charge into a container constructed for the sole purpose of retaining its heat as long as possible—a container such as a vacuum bottle, for example.—*Engineering Magazine.*

Effect of Moisture in the Earth on Temperature of Underground Cables

IN a paper on the above subject presented by L. E. Imlay at the Midwinter Convention of the American Institute of Electrical Engineers, and published in the *Proceedings* of the Society, the author describes a permanent installation which was made for supplying moisture to the earth in the neighborhood of underground cables with the object of reducing their temperature. The approximate temperature of the cables is found by taking with a resistance thermometer the temperature of a duct adjacent to the cable which is the source of heat. In uncovering the conduits and exposing them to air, as a remedy for hot spots in the cable, it was found that the adjacent earth was hot and dry so that it crumbled to powder. This suggested opening a ditch in the ground above the conduit and directing a stream of water through it. This was found to lower the temperature immediately several degrees. Where an open conduit was not practical, water was discharged into a vacant duct by means of a hose, and this was found to be more effective than the open ditch method.

These experiments led to the installation of a line of porous tile duct in the earth above the conduit, surrounded with clean sand. The leakage of water through the pores of this duct has been found very effective in reducing the temperature of the cables. Whenever the temperature of the cables is found by exploring with a resistance thermometer to approach the danger point, water is turned into the porous drain tile, and the temperature is taken on successive days to see whether the desired reduction has been obtained. In this way one or two men, with resistance thermometers attached to long leads, can keep track of and control the temperature of the cables in a large system. No breakdowns of insulation of cables have occurred due to high temperature since the adoption of this method.

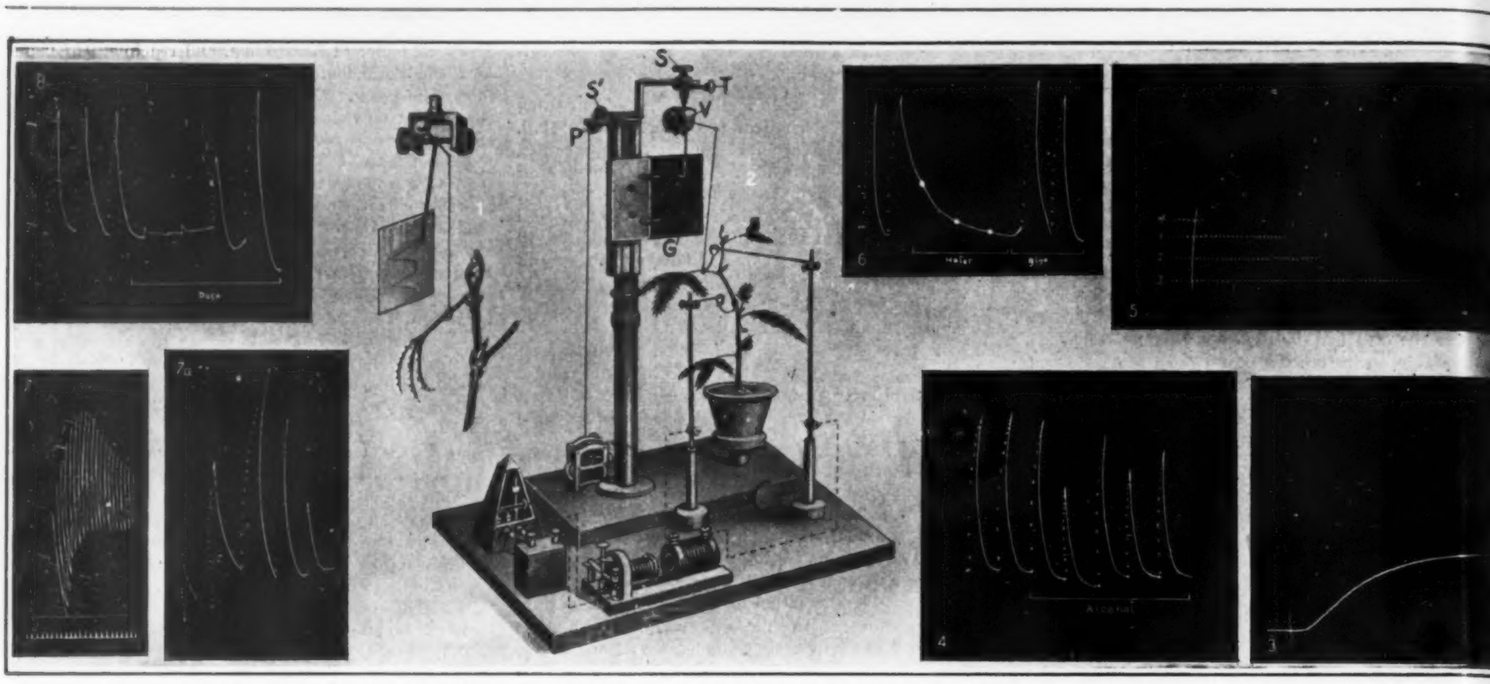


Fig. 1.—The essentials of a response recorder. Fig. 2.—General view of the resonant recorder. The thread from the clock passes over the pulley *P*, so as to lower the smoked recording plate G. The writing point is adjusted for distance by the screw *s'*; vertical adjustment is effected by the screw *S*; in order to adjust the plane of the recorder's movement parallel to the writing surface, a tangent screw *T* is provided. The picture shows also the electrical connections by means of which an excitatory shock of definite duration may be given to the plant by metronome which completes electrical circuit. Fig. 3.—The dotted line is correct, the continuous line incorrect, thus showing the advantage of intermittent over continuous contact in obtaining records. Fig. 4.—The effect of alcohol vapor; note the alternating character of the response after application. Fig. 5.—Effect of cold in inducing retardation and arrest of transmission: (1) normal record; (2) retardation due to slight cooling; (3) arrest of conduction brought about by intense cold; (4) record of direct stimulation. Fig. 6.—Effect of excessive absorption of water; note the prolongation of the period of recovery and the ineffectiveness of stimuli applied at moments marked with thick dots and subsequent restoration of excitability by application of glycerin. Fig. 7 and 7a.—Preliminary staircase followed by fatigue in the response of frog's muscle (Brodie) and staircase response followed by fatigue in Mimosa (Bose). Fig. 8.—Effect of sudden darkness on the excitability of Mimosa; first three responses normal; four succeeding responses due to the effect of darkness; the line below indicates the period of darkness.

Testing the Sensibility of Plants

The Remarkable Investigations of Prof. Jagadis Chunder Bose

STRIKE an animal and it winces. Strike a plant and it remains apparently unresponsive. Yet in the folk lore of almost every nation both animal and plant life are poetically unified, and the one credited with sensations akin to those of the other. Even those scientists who deal with the psychology of lower animal forms have felt that there was no reason to assume that response to external excitation should suddenly cease with the very low animal form and be denied almost together to plant life. These vague suspicions have at last been transformed into positive knowledge, thanks to the very remarkable studies which Prof. Jagadis Chunder Bose of Presidency College, Calcutta, has conducted for a period of many years and which have opened up an entirely new field in plant physiology.

Prof. Bose approached his task as a physicist, as might be expected of one who had distinguished himself for researches on electric waves which have become classic. From a man who has succeeded in producing an apparatus for producing the shortest waves, thus bringing our instrumental knowledge of radiation within thirteen octaves of visible light, who has determined the index of the refraction of various opaque substances, who has shown how total reflection fails when the thickness of the air space between two substances is shorter than a certain critical value, depending on the index of refraction and the wave-length, who has demonstrated the possibility of polarizing electric rays by various crystals, who has constructed two kinds of artificial molecules, which like dextrose and levulose, rotate the plane of polarization of electric waves to the right or to the left, who has demonstrated how substances which are strained in concentric circles, such as wood with concentric rings, project into space a dark electromagnetic cross, analogous to the dark cross exhibited by crystals, like salicine—from such an investigator one naturally expects extraordinary results. Realizing that the instrumental study of plant physiology has been hampered chiefly by the crudity of the apparatus employed, Prof. Bose invented a number of original types of recorders and originated startlingly new methods of investigation, with the result that he was able to demonstrate that all plants are sensitive and that they respond to stimuli as well as the higher animals. To those who wish a detailed account of these remarkable studies, we would recommend the reading of Prof. Bose's "Researches on the Irritability of Plants."[1] Upon this work the statements made in the following paragraphs are based.

Because of its very conspicuous motility, Mimosa has been made the object of much study on the part of plant physiologists, notably Haberlandt and Pfeffer. Prof. Bose also began with Mimosa. It is the one plant which, in popular acceptance, is conspicuously "sensitive." It ought to be no very difficult matter, apparently, to construct an apparatus which would record the movements of that mass of tissue in Mimosa which is known as the Pulvinus. We might construct an apparatus as shown in Fig. 1, consisting of an axis, supported on frictionless jeweled bearings and carrying two arms of a horizontal lever and a thin vertical wire with a bent tip to serve as a stylus or writer. A point of the petiole of the responding leaf could be attached by a silken thread to one arm of the lever, the other having on it a small weight to act as a counterpoise. When the leaf falls under excitation it ought to pull down with it the attached arm of the lever, and if the finely pointed bent end of the writer were to press lightly against the smoked surface of a glass plate, allowed to fall at a uniform rate by means of clockwork, a curve would be traced, which would not only record the responsive movement and recovery, but also give their time relations. The parts can be so proportioned that the degree of magnification or reduction of the movement of the leaf, as it appears in the record, could be very readily determined. However light the contact may be between the stylus and the glass plate in the type of apparatus sketched in Fig. 1, and however smooth the glass recording surface, the record will be inaccurate because of the friction entailed. How can this be overcome, so that an absolutely accurate record, free from error, could be obtained?

"It occurred to me at last," says Prof. Bose, "that the problem might find a solution if I could succeed in making an intermittent instead of a continuous writing contact. I have solved this problem by devising two different types of apparatus, which I have called, respectively, the oscillating recorder and the resonant recorder. In the former, the recording surface itself is made by an electromagnetic device to vibrate to and fro, thus bringing it into periodic contact with the writing point."

The resonant recorder is shown in its entirety in Fig. 2. A thread from a clock, not shown, passes over the pulley *P*, letting down the smoked recording plate; by means of the screw *S'*, the distance of the writing point from the plate can be adjusted; the vertical adjustment is effected by means of the screw *S*. A tangent screw *T* renders it possible to adjust the plane of the recorder exactly parallel to the writing surface; the axis of the writer is supported at the center of the circular end of the magnet; *V* is the vibrating recorder; and *G* is the smoked glass plate.

The reason for this peculiar construction will become apparent when we consider the nature of the investigations which must be made. Time intervals of one hundredths of a second must be measured. Clearly a heavy plate carrier cannot be made to oscillate with such a high frequency. Hence, Prof. Bose resorted to the device of making the writing point vibrate to and fro at the required frequency, so as to make the necessary intermittent contacts with the surface of the recording plate. A writing point made to vibrate to and fro at right angles to the plate will in no way affect the record beyond that fact that, instead of a continuous line, a dotted line will be traced. There is no friction resulting from continuous contact, and hence the record is accurate. The recording point must be given an impulse exactly perpendicular to the direction of its recording movement. In order that the electromagnet shall be without laterality, Prof. Bose makes the pole of the electromagnet in the form of either a cylinder or a ring. The axis, from which is suspended the writing index, is accurately supported perpendicular to the plane of the circular section of the magnetic pole and its center. Thus, everything is made symmetrical, and as there is no laterality there can be no tendency whatsoever for the index to execute its to and fro vibrations in any other direction than that which is perpendicular to the plane of the terminal pole of the magnet.

There is still to be overcome the difficulty of the irregular timing of these electrical impulses, which are to maintain the recording index or writer in a state of periodic vibration. Prof. Bose employs a long steel reed which in the course of its regular vibration will periodically interrupt the electromagnetic circuit of the vibrator coil. The reed itself is maintained in a state of persistent vibration by the usual electromagnetic arrangement. This reed interrupter he calls a "coercer"; the writing index he refers to as the "vibrating recorder" or the "vibrator." Obviously, if the natural frequency of vibration of the recording index is known and if by means of some mechanism we can send periodic currents of exactly the same frequency through the electromagnet, then the intermittent magnetic pulls will exactly synchronize with the natural swings of the writing index. Owing to this perfect tuning the index will now resonate, breaking out into a persistent and regular vibration of considerable amplitude. The various frequencies most suitable for the recording index are found to be ten, twenty, fifty, one hundred, and two hundred vibrations per second.

The enormous advantage of intermittent over continuous contact is shown in the record reproduced in Fig. 3. These represent two successive experiments on

[1] Longmans, Green & Co.

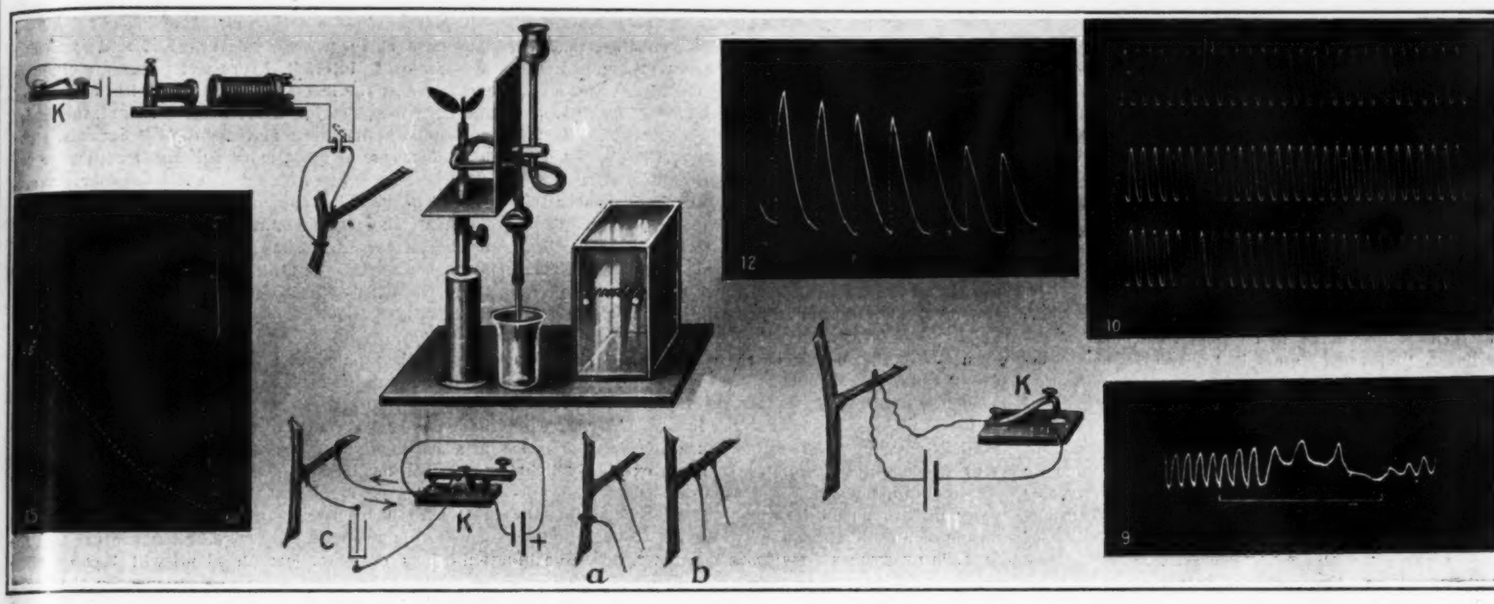


Fig. 9.—Strong carbonic acid gas, inducing arrest. The line below indicates the duration of the application. Slow revival of pulsation on substitution of fresh air. Fig. 10.—Continuous record of pulsation of Desmodium leaflet for four hours; the series to be read from below to above. Fig. 11.—Electrothermic stimulator for uniform stimulation; metronome is employed in place of key *k*, for closing circuit for a definite length of time. (Fig. 12.—Record showing growing fatigue of Mimosa. Fig. 13.—Direct stimulation by condenser discharge; *c*, condenser; *k*, key; *a*, intra-electrodal, and *b*, indirect extra-electrodal mode of stimulation. Fig. 14.—How detached leaflet of telegraph plant is mounted to study pulsations. The petiole is mounted in the shorter open end of a narrow U-tube filled with water. The longer end of the U-tube consists of India rubber tubing. By raising or lowering this longer limb the hydrostatic pressure can be varied. The stop cock allows the water to run out when chemical solutions are to take the place of water. A light cover with mica windows can be made to inclose the specimen. By means of an electric current sent through a spiral of German silver the inside of the chamber can be heated to any desired degree. Fig. 15.—The death-curve of Mimosa. Successive dots in the down or expansive part of curve represent rise of temperature of one deg. Cent. Spasmodic contraction causing inversion of curve takes place at 60 deg. Cent. with all plants. Fig. 16.—Arrangement for applying single make or break; *k*, key in the primary circuit. The secondary circuit may be short-circuited by the second key.

the same leaf and identical stimulation—an electrical shock The lower record was taken with continuous contact and the upper with the same recorder set in vibration so as to give intermittent contacts. The vibration frequency was ten times per second. A comparison of the record shows how enormous is the error due to friction. Moreover, it is obvious that the accurate dotted record is very easily interpreted, because the record itself contains its own time marks, the successive dots indicating intervals of one tenth of a second.

With the aid of this apparatus Prof. Bose has very accurately measured the response made by Mimosa and other plants under mechanical, chemical, thermal, and electrical excitation.

The thermal mode of stimulation deserves some explanation. It is illustrated in Fig. 11. A loop of the platinum wire is made to clasp around the petiole, which is to be excited, and is connected with an electrical circuit by means of fine flexible silver wire. The circuit can be completed by a metronome interrupter, the current of the battery flowing for a definite length of time during, say, a single or definite number of beats of the metronome. Successive uniform stimuli can be thus applied. Another practical method of stimulation is that of condenser discharge shown in Fig. 13. The condenser consists essentially of two conducting plates which may be two sheets of tinfoil, separated by a sheet of non-conducting material, such as mica or paraffined paper. The condenser is marked *C* and the key *K*. The intra-electrodal mode of stimulation is shown by diagram *a*, and the indirect extra electrodal mode of stimulation by the diagram *b*. About two volts, charging 0.5 microfarad, is, in general, found to be sufficient. When the key *K* is pressed down the condenser is charged, the instantaneous charging current passing in one direction. The upper arrow in this figure shows the direction of this charging current. When the key is released it springs back and discharges the condenser. The instantaneous discharge current now flows in a reverse direction. In Fig. 16 an arrangement for applying single make or break shock currents is illustrated, *K* being the key in the primary circuit, and the secondary circuit being capable of being short-circuited also by the second key.

Studied with the aid of the resonant recorder, different plants exhibit different characteristics of response. In studying the excitatory reactions of the plant under external stimulus it is first necessary to determine what time elapses between the incidence of the shock and the initiation of a perceptive responsive movement. This constitutes the determination of what is known as the "latent period." It is also desirable to ascertain at what rate this responsive movement of the leaf takes place and after what time the contractile phase of the movement is exhausted. After a short pause the plant gradually recovers from the effect of the shock and the leaf is re-erected to its former position. Hence, we would wish to know the various rates at which recovery gradually takes place.

Different plants exhibit different characteristics of response, Prof. Bose finds. The reactions are relatively quick in some and slow in others. In a typical case of Mimosa, in summer the latent period was one tenth of a second. The maximum fall of the leaf was attained in three seconds and the recovery completed in fifteen minutes. After the lapse of the latent period the leaf begins to fall, at first with increasing rapidity, which then again diminishes until it comes to a stop. The curve described attained a maximum amplitude, corresponding with the maximum fall of the leaf. The period required up to this point, Prof. Bose calls the "apex time." The rate of recovery in Mimosa is very rapid at the beginning and very slow toward the end. The maximum rate of recovery was 0.09 millimeter per second, in contrast with the maximum rate of fall of 24 millimeters per second. The movement of recovery is about three hundred times slower than the movement of excitatory fall. As the intensity of stimulus increases, the extent of responsive fall in Mimosa increases. Stronger stimulus and higher temperature have also a marked effect on the rate of movement; moreover, the rate of movement is decreased under fatigue. It is curious that a stronger stimulus, generally speaking, requires a longer period for recovery. Under the physiological depression induced by winter, the responsive reactions are modified, the latent period is prolonged and the amplitude reduced.

If, instead of giving the full period of rest necessary for complete protoplasmic recovery, the period of rest is shortened, a diminution in the height of response indicative of fatigue is noted in the record. This quite agrees with the exhibition of fatigue to be seen in muscle records in the same circumstances of diminished interval of rest. If a sub-tonic specimen be tested for fatigue, successive responses are found to undergo a gradual enhancement, or what is known in muscle response—with which it is exactly parallel, as a staircase increase shown in Figs. 7 and 7a. When deprived of the invigorating influence of favorable surroundings a plant becomes sub-tonic.

Under the action of successive stimuli the tonic condition is improved. The loss of tone, with its consequent relaxation, will gradually give place to a better tone with increasing tonic contraction. Hence, the gradual bettering of tonic condition under successive stimulations may often find two simultaneous expressions. In the first place, the growing tone with its increasing normal tonic contraction will be seen in the shifting of the base line upward. Secondly, it will be exhibited in the growing amplitude of successive responses. Thus are to be explained the very remarkable records shown in Figs. 7 and 7a.

In order to demonstrate the variation of excitability induced by sudden diminution of light, Prof. Bose takes a set of three normal responses in diffuse daylight. The chamber in which the plant is confined is then suddenly darkened by means of an opaque screen. It will be noticed in Fig. 8 that the next two responses are nearly abolished; the excitability of the plant was, however, beginning to be restored after forty-five minutes' exposure to darkness. After an hour in darkness the excitability was fully restored, the response here being even larger than in light.

Prof. Bose noticed in Mimosa a depression of excitability on rainy days. This effect he was afterwards able to trace to the absorption of water by the pulvinus. The variation of motile excitability by absorption of water is very clearly exhibited in Fig. 6. A pair of normal uniform responses were first taken. A drop of water was then applied on the pulvinus, when the leaf was recovering from the second stimulus. The period of recovery was obviously very much protracted in consequence of absorption of water. The usual time for complete recovery is about fifteen minutes. In this case it was prolonged to forty-five minutes. The plant was obviously gorged and inactive as a consequence.

The effect of various gases upon plants has been studied with the greatest care by Prof. Bose. Ozone stimulates; carbonic acid gas, undiluted, depresses. The vapor of alcohol produces intoxication, which is quite apparent in the record, as shown in Fig. 4. Moreover, the continued action of alcohol vapor induces depression.

That a plant may be killed as well as an animal every one of us knows. But when does it actually expire? Plants that have been dead for hours are to the eye as fresh as if they were alive. One method by which the occurrence of death may be determined, Prof. Bose finds, is the abolition of that electric response which is characteristic of the living condition. A plant, as long as it is alive, gives in answer to a stimulus a galvanometric response. On the occurrence of death this particular response disappears. He finds that the electric response is abolished when the plant has been subjected for a time to a temperature of about 60 deg. Cent. The plant is placed in a water bath and the temperature of the bath is continuously raised by the application of a gas or spirit flame, very gradually of course, so that there may be no sudden variation or sudden excitation. In Fig. 15, the record was commenced at 25 deg. Cent., and the successive dots in the record are at intervals of 1 deg. Cent. The down curve indicates the expansive erection of the leaf. As soon as the temperature had reached 60 deg. Cent. there was an abrupt inversion and the spasmodic contractions took place at a very rapid rate. The successive dots in the upper portion of the curve are at intervals of 0.2 of a degree. The point of inversion indicates the death point, and the curve giving the death record may be regarded as the death curve. All attempts to stimulate a plant and to receive a response fall after the death curve has once been recorded. It is obvious, therefore, that the plant is really dead. At 60 deg. Cent. the last response given by plants invariably seems to occur. In taking an electrical record, it is found that an electric spasm also takes place at the critical temperature, which is very near 60 deg. Cent. The death point of the plant, moreover, is found to be lowered under physiological depression. Thus, under fatigue induced by tetanizing electric shocks, the death point is lowered from the normal 50 deg. Cent. to 37 deg. Cent. Poisonous re-agents also lower the death point. In a particular case Prof. Bose found that a poisonous solution of copper sulphate lowered the death point by 18 deg. Cent.

If a plant is thus responsive to external influences, if, in a word, it is sensitive in a very real sense, we may well ask whether there is a transmission of a true

excitatory change in the plant, and if so, whether there is in it any specific conducting tissue corresponding with the nerve of the animal for the conveyance of excitations. It is known that the excitation of a living tissue is attended by a concomitant electric change of galvanometric negativity. If we make suitable galvanometric electric connections with two points on a nerve, and we stimulate the nerve at a distant point, we shall find that the arrival of excitation from the distant stimulated point is, at a proper moment, signalized in the galvanometer by a deflection of a definite sign. Similarly, Prof. Bose has found that the excitatory change of galvanometric negativity is transmitted through a distance to certain plant organs. Tissues containing fibro-vascular elements, such as stems and petioles, are found to be good conductors of excitations. Indifferent tissues in leaves and tubers possess little power of conduction; in such cases excitation remains more or less localized. By applying stimuli of constant intensity and by allowing proper intervals of rest, successive values of velocity of transmission of excitation are obtained which are constant. Automatic records have been obtained showing a time interval as short as 0.05 second. The highest velocity of transmission of excitation Prof. Bose found in the petiole of Mimosa to be 30 millimeters per second. Prof. Bose has been able to show that excitatory reaction is initiated in the petiole of various sensitive plants by the discriminative polar action of an electric current. Excitation is induced at the cathodic point at make and at the anodic point at break. Transmission of such an excitatory impulse takes place in the absence of all mechanical disturbances. Freeze the plant or apply cold locally, and the conducting power is abolished. Poison the plant locally and conductivity is again destroyed. It is evident that excitatory impulses are conducted in plants quite as they are in animals.

In certain plants, such as the telegraph plant of India, spontaneous movements of a rhythmic character may be observed. A very remarkable study of this plant which Prof. Bose carried out shows that these rhythmic pulsations of the telegraph plant leaflets may be correctly likened to the pulsations of animal heart tissue. Because a large plant cannot easily be manipulated, Prof. Bose experiments with the detached petiole carrying the pulsating leaflet. As in the case of the isolated heart in a state of standstill, the movement of the leaflet can be renewed in the detached specimen by the application of internal hydro-static pressure. Under these conditions the rhythmic pulsations are easily maintained uniform for many hours (Fig. 10). As shown in Fig. 14, the petiole after detachment is put in water and mounted watertight, in the shorter open end of a narrow U-tube filled with water. The longer end of the U-tube consists partly of India rubber tubing. By raising or lowering this longer limb of the U-tube, the hydrostatic pressure to which the specimen is being subjected can be varied; different chemical solutions can also be applied internally by its means; a stop-cock allows the water to run out of the U-tube, making way for the particular solution poured in at the open end of the tube. The resonant recorder shown in Fig. 2 would not be able to trace records of the smallest movements of the leaflet. The leaflets have a pull which is so very feeble that the inertia of writer cannot be overcome. As the pull exerted by the leaflets is very feeble, the writer must be made extremely light. The oscillating recorder has been devised for this purpose; an instrument in which the recording plate, by means of an electric motor provided with an eccentric, is made to execute a reciprocating movement. The intermittent dots thus produced may be one in each second or one in two seconds. As the oscillating recorder permits the employment of a light grass haulm for the recorder, a fair magnification in the record may be obtained. Prof. Bose has used both methods, resonant and oscillating, for obtaining the records. In the former they appear continuous; in the latter dotted. But when it is desirable to obtain data for accurate time measurements of different plastic movements of the leaflet the oscillating recorder is employed.

As an example of the extreme regularity which can be secured in the pulsating movements of such specimens, the record shown in Fig. 10 may be studied with interest. This is a continuous record lasting for four hours, the movements themselves being maintained uniform for more than seven hours. The run of the breadth of the plate was accomplished in one hour and twenty minutes, successive series of records being taken on the same plate from below to above. Prof. Bose found that the application of shock to a leaflet in a state of standstill induces a down movement. The phase of the down movement is, in general, quicker. Enforced expansion by increased internal hydrostatic pressure induces movement of the leaf upward. In a typical example of the rhythmic pulsation of the telegraph plant, the leaflet accomplished its down movement in 41 seconds. The maximum rate of down movement is 0.9 millimeter per second, the average rate being 0.44 millimeter per second. The period of up movement is longer, being 60 seconds. The maximum rate of up movement is 0.56 millimeter per second, the average rate being 0.3 millimeter per second. In the rhythmic pulsation of a frog's heart variation of temperature changes the period and modifies the amplitude of pulsation. Prof. Bose has been able to prove that the lowering of temperature has on the telegraph plant precisely the same effect. The rhythmic pulsation of the cardiac tissue is arrested when subjected to a certain low temperature. Similarly, the pulsation of the telegraph plant is arrested at a sufficiently low temperature. The critical point is somewhat modified by the condition of the specimen. With vigorous specimens the temperature at which arrest takes place may be as low as 17 deg. Cent. The converse is also true. Increase the temperature and the pulsations of the telegraph plant will become more marked. Alcohol has a marked action upon the heart. What is its effect upon the telegraph plant's leaflets? Prof. Bose found that strong alcohol solutions induce a depression which may permanently arrest the pulsation, exactly as in the case of cardiac tissue. The effect of carbonic acid gas is shown in Fig. 9. Diluted with air, this gas causes an enhancement of amplitude, though the period becomes longer. Fresh air produces a revival of normal pulsation. Ether produces at first a transient exaltation, followed by depression and arrest of pulsation. More pronounced is the effect of chloroform, which is far more toxic in its action. Carbon disulphide arrests the pulsating activity of the plant. Copper sulphate also produces an arrest of pulsation. So powerful is the poisonous effect of potassium cyanide solution that rhythmic activity of the telegraph plant is very quickly abolished. The effect of acids and alkalis on the rhythmic movements of the telegraph plant are, as on the animal heart, antagonistic.

What Happens When Gunpowder Explodes*

The basis of modern smokeless powder is guncotton, to which a great variety of forms can be given, but the efficiency of the explosive is greatly increased by an admixture of nitroglycerine. To synthetic chemistry we owe both smokeless powder and the high explosives which are used for filling shells and bombs. Picric acid was first employed for this purpose, instead of black gunpowder, about 30 years ago, but for the last 10 years picric acid has been superseded by trinitrotoluol, which satisfies the requirements better than any other known explosive.

The explosion of a charge of powder in a rifle or a cannon is designed to impel the projectile forward with gradually increasing velocity, without endangering the integrity of the gun by excessive gas pressure. The charge of a shell, on the other hand, is designed to shatter and destroy by generating the maximum pressure in the shortest possible time.

The pressure caused by explosion depends, in the first place, on the quantity of gas generated, which can be measured by exploding a small known quantity of the powder in a very strong, thick-walled shell, connected with a gasometer. In this way it is found that black gunpowder produces 290, guncotton 950, and trinitrotoluol 970 liters of gas, per kilogramme of explosive, the gas being measured at atmospheric pressure (760 millimeters) and at 0 deg. Cent.

The pressures developed in large artillery guns are very great, varying from 2,000 to 3,000 atmospheres. In order to withstand these enormous pressures the guns are made of nickel-steel, chrome-steel and other improved steels, some of which are so strong that they resist even the premature explosion of a shell in the gun. The improvement that has been made in gun material is shown in the following table in which "tensile strength" is the weight, in kilogrammes, required to pull asunder a bar one centimeter square; "elastic limit" is the weight required to produce permanent increase in length, and "extensibility" is the percentage of the original length by which the bar is stretched at the instant of rupture. The extensibility furnishes a measure of the toughness of the material.

	Tensile strength.	Elastic limit.	Extensibility.
Cast iron.........	2,340	1,110	0.4
Common steel.....	4,200	2,440	11.5
Nickel steel.......	7,500	4,400	18.0

* Adapted from *Naturwissenschaftliche Wochenschrift*, as quoted in *Die Umschau*.

Special construction, as well as strong materials, are required to withstand the pressures developed by modern explosives. A cannon is now always composed of several parts, so arranged that the outer parts exert pressure upon the inner parts even when the gun is not in use. This principle has led to the construction of mantled and ringed guns in Germany, and of wire-wound guns in England.

Gun-makers have devoted much attention to the problem of making the powder chamber gas-tight. With cartridge ammunition the brass shell of the cartridge furnishes the required closure behind. In guns of larger caliber the same result is accomplished by means of packing rings of soft copper. In front, gas-tight closure is effected by the projectile which is pressed tightly into the rifling.

The explosion of the projectile is accompanied by a reaction, called the recoil, which impels the gun backward. Even in field pieces the force of the recoil may amount to 100 tons, and it is proportionately greater in large naval and siege guns. This tremendous shock must, of course, be taken up by the mounting of the gun.

The rate at which the gas pressure is developed is as important as its maximum value. It has not been found possible to measure directly the variations of pressure during the discharge, but they have been determined indirectly by recording the passage of the projectile through the bore. The gas pressures can be deduced from the measured velocities of the projectile in the bore.

The ideal condition would be constant pressure from the start of the projectile to its emergence from the muzzle, but this condition cannot be realized. The pressure increases as long as the effect of the liberation of fresh gas exceeds the effect of the space added by the advance of the projectile. The pressure diminishes from this point, and drops suddenly to atmospheric pressure when the projectile leaves the gun. The velocity of the projectile varies in a similar manner, attaining a maximum value at a certain point, and diminishing somewhat toward the muzzle.

The energy of an explosive is determined by the heat produced by its explosion, or combustion. Only 10 to 35 per cent of this energy is transformed into the kinetic energy of the projectile, the rest being consumed in overcoming friction, heating and expelling the gases, producing the recoil of the gun, etc.

The heat of combustion of an explosive is measured by exploding a small quantity in a strong shell immersed in a water calorimeter with a delicate thermometer. In this way it is found that black gunpowder produces 750, guncotton powder 940, nitroglycerine powder 1,330, and trinitrotoluol 720 calories per kilogramme of explosive, a calorie being the quantity of heat required to raise the temperature of one kilogramme of water 1 deg. Cent. These values are much lower than those obtained with many non-explosive combustibles, but the rapidity of explosive combustion produces very high temperatures. The temperature of explosion has never been measured directly but it can be calculated approximately from the heat of combustion of the explosive and the specific heat of the gases produced. Thus the explosion temperature of a powder used in infantry rifles in Germany is estimated at 2,100 deg. Cent. These high temperatures greatly increase the gas pressure and the velocity of the projectile, but they also shorten the useful life of the gun.

The velocity with which ignition progresses in explosives is astonishingly great. In picric acid it is 8,000 meters (about 5 miles) per second. Loose guncotton is completely consumed in 0.0004 second, black gunpowder in 0.0015 second when finely pulverized, 0.0057 second when in granular form, and 0.0084 second when strongly compressed. Hence it appears that the velocity of ignition is affected by the density of the explosive and is greatly diminished by compression. The velocity of ignition depends also on the space available for the explosion. The explosion of a heavy charge in a very small space produces intense pressure, which accelerates the combustion. In modern practice the charge of smokeless powder which is used about half fills the powder chamber.

Accurate knowledge of the ignition velocity is necessary in order to determine the efficiency of a powder. The ideal powder would be completely consumed exactly at the instant when the projectile emerges from the gun. This condition is not attained in practice. A flame which indicates unfinished combustion always issues from the mouth of the gun. In some conditions, this flame may go far toward counterbalancing the advantages of smokeless powder.

Explosives differ very greatly in sensitiveness, or liability to explosion by mechanical shock. The sensitiveness is measured by letting a weight fall on the explosive from a height which is gradually increased until explosion occurs. The height through which a weight of 2 kilogrammes must fall in order to produce explosion is 1 centimeter for fulminate of silver, 25 centimeters for picric acid, and 108 centimeters for trinitrotoluol. This shows the superiority of trinitrotoluol to picric acid in in point of safety. The excessively sensitive fulminate is used only as a primer.

The Gatun Dam*

By C. D. Ward, M. Am. Soc. C. E.

In a paper,[1] entitled "Inter-Oceanic Canal Projects," by A. G. Menocal, M. Am. Soc. C. E., it is stated that the Government Commission, appointed in 1875, reported, as to a canal with locks, from Colon to Panama, as follows:

"The river (Chagres) is proposed to be crossed by means of an aqueduct having twelve spans of 90 feet each, 1,900 feet extreme length, 65 feet wide, and 26 feet deep.

In discussing this paper,[2] the late Ashbel Welch, past-president, Am. Soc. C. E., a thorough and noted canal engineer in his day, said:

"The first thought of an American canal and river engineer, on looking at M. de Lesseps's raised map, is to convert the valley of the lower Chagres into an artificial lake, some twenty miles long, by a dam across the valley at or near the point where the proposed canal strikes it a few miles from Colon, such as was advocated by Mr. C. D. Ward."

The site proposed for this dam was at Gatun, 7.5 miles from deep water at Colon, the end of the canal. But, as is well known, the use of locks was not to be thought of under M. de Lesseps domination, and a sea-level canal was commenced in 1883.

In 1887 it was at last decided that locks would have to be used, and from that time to the present, various locations and elevations for the necessary locks have been suggested, and different sites for the great dam selected.

The New Panama Canal Company and the Isthmian Canal Commission of 1899, the latest authorities, agree in locating the dam near Bohio, 16.5 miles from deep water at Colon, or 9 miles farther up stream than Gatun, the location suggested by Mr. Welch in 1880.

Furthermore, the Isthmian Canal Commission says in its report that "no location suitable for a dam exists on the Chagres River below Bohio."[3]

The late George S. Morison, past-president, Am. Soc. C. E., a member of the Isthmian Canal Commission, commenced his paper on the Bohio dam, which was presented to this society on March 5th, 1902,[4] with this sentence:

"All engineers who have examined the route of the Panama Canal agree that the neighborhood of Bohio is the only available location for the dam by which the summit level must be maintained."

Neither of these authorities mentions or gives any consideration to the project of a dam at Gatun, nor even condemns it; nor is the writer aware that any soundings or other examinations, looking to a dam at this point, have ever been made.

As this question may be worthy of more consideration than it seems to have received, some of its advantages may be stated. The canal, as proposed by the latest authority, the Isthmian Canal Commission, may be briefly described as follows: From deep water in Colon harbor to the Bohio locks, the Atlantic maritime level, cut mostly through the low flat valley of the Chagres, will be 16.81 miles long. The two Bohio locks, with a lift of 45 feet each, reach the Bohio lake, formed by the Bohio dam, with a maximum elevation of 90 feet above tide in Colon harbor and an area of 38.5 square miles. The summit level thus attained extends through the Culebra cut. The distance from the Bohio locks to the Culebra cut is 13.61 miles, and from thence through the Culebra cut to the Pedro Miguel locks at the farther end of the level the distance is 7.91 miles. The maximum combined fall of these two locks is 62 feet. From Pedro Miguel locks a level of 1.33 miles extends to Miraflores lock, which has a maximum fall of 38 feet to mean low tide in Panama harbor. For a distance of 4.12 miles beyond this lock the canal extends, through the low swampy country in which the Rio Grande flows, to a point known as La Boca, on the edge of Panama Bay. A dredged channel extends from this point 4.41 miles to the 6-fathom line in Panama Bay.

Allowing 0.90 mile for the various locks, the total length of the canal is 49.09 miles.

As to the suggested dam at Gatun, the New Panama Canal Company has made a contour map of the region where the dam would probably be located, if at all. If a dam were built here, impounding the water to an elevation of 90 feet, then, of course, the Bohio dam and the locks and spillway would be omitted, and locks would be built at Gatun.

The length of the dam would be 6,750 feet, while the length of the Bohio dam is 2,546 feet. The area of the section is nearly three times that at Bohio; therefore, it might not be out of the way, for the present, to say that the cost of the Gatun dam would possibly be three times that estimated for the Bohio dam, or $19,108,920. At present, there seems to be no reason to think that the locks would cost more at one place than at the other, but the spillway should be somewhat longer, and might cost more. There may be a question whether the hills to the west of Gatun are high enough to contain the Gatun lake at an elevation of 90 feet, but the raised map made by the New Panama Canal Company, a reproduction of which is to be seen at Columbia University, indicates sufficiently high ground. The lake would extend far up the valley of the Rio Gatun on the east and the Rio Trinidad on the west, and submerge the Chagres Valley for 9 miles, including the Aqua Clara, Pena Blanca, Vino Tinto, and Bruja Swamps, cover 20 or 30 square miles of swampy land, and thus improve the healthfulness of the country. This lake area added to the 38.5 square miles of the Bohio lake would be a benefit in every way and would render the Alhajuela dam on the Upper Chagres unnecessary. Between Gatun and Bohio the excavation of the sea-level canal, the Pena Blanca swamp outlet to Aqua Clara swamp, the Chagres diversion from Aqua Clara swamp to near Gatun and the diversion of the Rio Gatun, would become unnecessary, and their cost would be saved. These items amount to $14,635,604, a sum large enough to pay the assumed extra cost of the Gatun dam and leave about $2,000,000 to pay for changing the line of the Panama Railroad and the possible additional cost of the spillway. If these assumptions should prove practicable, the result would be a better and safer canal, shorter time of transit, and more healthy conditions, all at no greater cost and with lower maintenance changes.

*This paper was presented at the meeting of the American Society of Civil Engineers, May 18th, 1904. It is reproduced here for the purpose of showing that in 1904, or one year before the Board of Consulting Engineers appointed by President Roosevelt adopted the plan for a lock canal, Mr. Ward had formally advocated the construction of the dam at Gatun. Colonel G. W. Goethals, in a letter to Mr. Ward wrote in 1907: "The service you rendered in calling attention to the feasibility of the Gatun Dam, in a paper presented to the American Society of Civil Engineers, is recognized by the Engineering Committee." Editorial discussion of this paper will be found in the current issue of the SCIENTIFIC AMERICAN.

[1] *Transactions*, Am. Soc. C. E., 1879, vol. viii, p. 311.

[2] *Transactions*, Am. Soc. C. E., 1880, vol. ix, p. 148.

[3] "Report of the Isthmian Canal Commission," 1899-1901, p. 90.

[4] *Transactions*, Am. Soc. C. E., vol. xlviii, p. 235.

Printing for the Blind

One of the noblest works of man has been his efforts to lead his blind brother, and especially to enable him to read by his sense of touch. A number of publications for the blind are shown in an exhibit of the Graphic Arts division of the U. S. National Museum in the Smithsonian building. The first efforts in this connection are credited to a Spaniard named Francesco Lucas, who planned the engraving of letters on blocks in the sixteenth century. His scheme was followed in 1640 by a system of cast lead letters planned by Pierre Moreau of Paris, who unfortunately had not the means to carry out his idea. There followed systems of different sorts: pins set in cushions, wooden letters, the movable metal letters of Du Puiseaux, the letters cut in cardboard, and pricked maps made by R. Wiessemburg, a German, with which he succeeded in teaching Mlle. Paradis, a talented musician.

The honor of being the first to introduce printing for the blind in raised characters, like embossing, is attributed to Abbe Valentin Hauy of Paris, who effected his plan in 1784, the result of his accidentally discovering that his blind pupil could read parts of a printed card heavily indented by the types. Relief printing was the result.

James Gall of Edinburgh embossed several elementary works and was the first to conceive the idea of printing the Bible for the blind; he completed the Gospel of St. John in 1834. His system employed the common English letter but replaced the curves by angles. Printing for the blind was commenced in the United States in 1833, at Boston and Philadelphia. Improvements were made by Friedlander, Lucas, Wait, Frere, Howe, and Kneass. Dr. S. G. Howe of Boston established a system in which he used the lower case English letter without capitals, and like Gall, with angles instead of curves. In this manner he printed the entire New Testament in 1838 and completed the Bible in 1843.

A method clearly meant for adults and persons whose fingers are not as sensitive as those of youth, was effected by Dr. William Moon of England in 1847. This preserved part of the outline of the Roman letters, but was nevertheless one of the arbitrary systems and is too unwieldy for general use. One feature of this style is the guide for the reader's finger at the end of the lines; the even numbered lines are read from right to left.

The arbitrary point system was invented early in the nineteenth century by Capt. Charles Barbier, a French officer, who substituted embossed dots for lines. This was arranged in its present form by Louis Braille, a pupil who afterward became a professor in an institution for the blind in Paris. As it is used to-day, this system comprises combinations of six dots arranged in two vertical lines of three each, making possible sixty-three different combinations. "N" is represented by ⠝, and "T" by ⠞, while ⠯ stands for "and."

Naturally, the alphabetical systems are of advantage over those of an arbitrary nature, since they may be read by seeing persons with ease, enabling anyone to read or teach from such books, while a special teacher is required to instruct in the others.

The first books for the blind were very bulky, and many attempted to decrease their size and consequently the cost. They are still voluminous, however, three more volumes than are required for an ordinary encyclopedia being required to complete Defoe's "Robinson Crusoe." One of the several books to be seen in the collections in the Smithsonian building is a bulky volume of this work.

The chief American systems are J. R. Friedlander's Roman capitals, in which has been printed the only dictionary for the blind; Howe's angular lower case letters; the French alphabet with capitals and rounded lower case letters; and Kneass's improved system combining capitals and angular lower case letters, the lower case letters with tails being raised so that no part extended below this line. The last style was the innovation of a blind writer, N. B. Kneass, Jr., who also established a magazine for the blind in 1867.

The Graphic Arts exhibit contains samples of the Kneass system and a copy of his Philadelphia *Magazine for the Blind*. Publications of the Howe Memorial Press of Boston, the American Printing House for the Blind of Louisville, and specimens of the Moon and Braille systems are also shown, together with relief maps and illustrations.

Electrolytic Iron Melted in Vacuo

At a meeting of the Urbana Section of the American Institute of Electrical Engineers an interesting paper was read by Trygve D. Yensen on the above subject. The following abstract of the author's remarks is derived from the *Proceedings* of the Institute, in which the paper was published:

Electrolytic iron of a purity of 99.97 to 99.98 per cent was melted in fused magnesia crucibles in a modified Arsem furnace, forged into rods, machined, and annealed in an electric furnace according to various heat cycles.

The magnetic properties were obtained by the Burrows double bar method. Determinations were also made of the electrical resistance, chemical composition, and physical properties, including microstructure and critical temperatures as well as tensile tests. A few commercial iron and steel samples were tested for comparison.

The following valuable results were obtained:

1. Pure iron melted in an atmosphere of carbon monoxide under atmospheric pressure will absorb both carbon and oxygen, with the result that the iron thus produced is of an inferior magnetic quality.

2. Low carbon iron melted *in vacuo* will lose 50 to 90 per cent of its original carbon content.

3. The magnetic quality of electrolytic iron melted *in vacuo* is decidedly superior to any grade of iron thus far produced, the maximum permeability obtained being 10,000 at a flux density of 9,500 gausses. The average hysteresis loss obtained is less than 50 per cent of that found in the best grade of commercial transformer steel, due to the fact that the coercive force is very much lower than for silicon steel, although the retentivity is higher.

4. The specific electrical resistance of pure iron melted *in vacuo* is 9.96 microhms per centimeter cube.

5. Swedish charcoal iron melted *in vacuo* has a magnetic quality approximating that of electrolytic iron melted *in vacuo*, chiefly due to the reduction of the carbon content.

The author suggests that the high electrical conductivity and hence large eddy current losses in this material may possibly be greatly reduced by the addition of silicon or aluminium without very materially affecting the magnetic quality.

A cement for fastening metal to marble is given in the *American Machinist*. It consists of thirty parts plaster of paris, ten parts of iron filings, and half a part of sal-ammoniac. These materials are mixed and acetic acid added to make a thin paste, which must be used immediately.

A South American jungle along the Paraguay.

The Roosevelt-Rondon Scientific Expedition—I*

Its Movements in South America and Some of Its Zoological Achievements.

By L. E. Miller, Mammalogist of the Expedition

The plan of the expedition, fully decided upon after consultation with the Brazilian government on arrival at Rio de Janeiro, took shape as follows: to ascend the Paraguay to the highest navigable point, cross the vast breadth of Matto Grosso on mule-back and descend the unexplored Rio de Dúvida. It was decided also that the main purpose of the expedition should be an exploration of the Rio da Dúvida with zoological collecting as we moved along or as opportunity presented itself.

The steamship "Vandyck" remained at anchorage in the harbor of Rio de Janeiro two days, which gave us ample time to view the natural scenic wonders of the harbor, and the beautiful city. The greater part of one day was spent in the botanical gardens which with the avenues of stately royal palms and large collections of plants from all parts of the tropical world, doubtless surpass anything of a similar nature found in South America. Here Colonel Roosevelt left the party, accompanied by his son Kermit and Doctor Zahm; the remainder of the expedition consisting of Mr. George K. Cherrie, Mr. Jacob Sigg, Mr. Anthony Fiala and myself, resumed the voyage and reached Buenos Aires six days later (October 27th), 23 days after leaving New York. We had stopped a day at Santos, Brazil's great coffee center, and another at Montevideo, the capital of Uruguay.

Mr. Cherrie and the writer were eager to devote every available moment to the zoological work, so leaving Messrs. Fiala and Sigg, whose duty it was to look after the handling of the large amount of impedimenta, we secured passage on the Argentine Northeastern Railroad, which had just inaugurated through service to Asunion, Paraguay. We took only the small amount of equipment necessary for a few weeks' work as the two others were to come up with the remainder of our luggage via the first available freight boat. Our train was the second to make the through trip, and was scheduled to run bi-weekly. It was composed of seven Pullmans, two baggage cars and a dining car, and the service was good. Leaving Buenos Aires on the afternoon of Sunday, November 2d, we reached Rosario at about dark. Here the train was run on to a steel boat and carried up river for about 4 hours, after which it continued the journey on the east bank of the Paraná. The next night we recrossed the river on a ferry boat and were landed at Encarnacion, Paraguay. Asuncion was reached late in the afternoon of Tuesday.

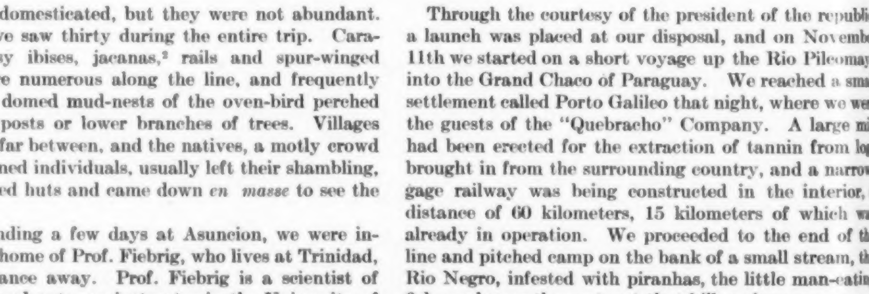
The railway journey had been through level plains country, interspersed at long intervals with small clumps and strips of low woods; but it is essentially a grazing country, and we passed numerous herds of cattle contentedly grazing in the vast, fence-inclosed ranges. Stalking calmly among the herds were small bands of rheas, semi-domesticated, but they were not abundant. I doubt if we saw thirty during the entire trip. Caracaras,[1] glossy ibises, jacanas,[2] rails and spur-winged plovers, were numerous along the line, and frequently we saw the domed mud-nests of the oven-bird perched upon fence posts or lower branches of trees. Villages are few and far between, and the natives, a motly crowd of dark-skinned individuals, usually left their shambling, grass-thatched huts and came down *en masse* to see the train.

After spending a few days at Asuncion, we were invited to the home of Prof. Fiebrig, who lives at Trinidad, a short distance away. Prof. Fiebrig is a scientist of more than local note, an instructor in the University of Paraguay and curator of the museum. Our first zoological work was done on his estate. All about were tracts of low forest of considerable size, patches of brush country, grassy fields and cultivated plots. Birds were very abundant, and as practically everything was new to us, our work was doubly interesting. We here formed our first intimate acquaintance with the peculiar white ani[3] (*Guira*), large flocks of which were in the palm trees. The birds sat soberly on their perches, awkwardly jerked their tails from side to side and mewed dolefully. They seemed to be utterly out of place among the vivacious tanagers, creepers and finches, and to belong more properly to the fauna of some remote and unrecorded past. Mammalian life was scarce, but considering the short time available, a comparatively representative collection was made, including a series of a small rare wolf (*Canis*).

Through the courtesy of the president of the republic, a launch was placed at our disposal, and on November 11th we started on a short voyage up the Rio Pilcomayo into the Grand Chaco of Paraguay. We reached a small settlement called Porto Galileo that night, where we were the guests of the "Quebracho" Company. A large mill had been erected for the extraction of tannin from logs brought in from the surrounding country, and a narrow-gage railway was being constructed in the interior, a distance of 60 kilometers, 15 kilometers of which was already in operation. We proceeded to the end of the line and pitched camp on the bank of a small stream, the Rio Negro, infested with piranhas, the little man-eating fish, no larger than a trout that kills swimmers.

Our camp was merely a rough shed built of sheets of corrugated iron supported on poles driven into the ground. The river water was salt and unfit for use, so each morning several large jugs of drinking water were sent us from Porto Galileo, together with a supply of fresh provisions. All about lay marshes, swamps and large grass-covered areas, the latter type of country predominating.

It is in the dark swamps that the precious quebracho trees grow. It was also from these same swamps that clouds of ravenous mosquitoes issued with the first signs of failing daylight, and drove us to the refuge of our net-covered hammocks. There we sweltered through the long hours of the night, listening to the angry buzzing of our outwitted assailants, which was not unlike the sound produced by a swarm of enraged bees. I could distinguish a number of different pitches and qualities in the music, blending harmoniously in one general chorus. The varying size of the insects, which ranged from individuals nearly an inch long to small, infection-bearing



Part of the expedition camp at Utiarity.

* From the *American Museum Journal*.

[1]Caracara: a member of the hawk family.

[2]Jacana: a bird that combines certain characteristics of both plover and rail.

[3]Member of a subfamily of the cuckoos.

Utiarity Falls, South America, two hundred and fifty feet high.

Anophelcs, doubtless accounts for the different tones produced by the vibrations of the wings. Small brockets[4] were plentiful in the swamp and came out into the fields to feed morning and night, and in the tall grass, cavies[5] abounded. Ocelots had worn well-defined paths through the fields in their nightly raids on the cavy community. In the trees we found black howlers, night monkeys and tayras[6]; on the ground, opossums and various small rodents held sway. When time permitted us to take a few moments' recreation, we fished for piranhas[7] in the stream, the ravenous creatures throwing each other clear of the water in their frantic struggles to get at the meat bait.

After a profitable week's work on the Pilcomayo we returned to Asuncion, where we were joined by the two commissaries who had just arrived with the equipment. Two days later we boarded the comfortable little steamer "Asuncion" and sailed for Corumbá. The four and a half days' trip on the Paraguay was most interesting, although the heat was intense and insects at times were troublesome. We had entered the great *pantanal* country, and the vast marshes teemed with bird life. As the "Asuncion" plowed her way through the water, countless thousands of cormorants and anhingas[8] took wing; lining the pools and dotting the marshes were hordes of wood and scarlet ibises, together with herons and a sprinkling of spoonbills; egrets covered the small clump of trees as with a mantle of snowy white, and long lines of jabirus patrolled both shores. Scarcely a moment passed in which we did not see hundreds of birds. Many of the passengers were armed with rifles and revolvers, with which they kept up more or less of a fusillade on the feathered folk, but fortunately their aim was poor so that little injury was inflicted. The day before reaching

Nhambiquare men, wearing labrets.

Corumbá we passed an interesting old land-mark, the fort of Coimbra, built on a rocky hillside with a cluster of thatch-roofed huts nestling against the base. It is near the Bolivian border and in by-gone years figured prominently in several of the bloody controversies between the neighboring republics.

Having heard of a place called Urucúm, but a short distance away, which seemed to offer unusual opportunities for collecting, Mr. Cherrie and the writer immediately moved to that place and established headquarters. Urucúm proved to be a garden spot of clear, cold springs, shady groves, and plantations of tropical fruits and vegetables. Easy of access were fields, forested hillsides, marshes and lagoons in which dwelt an abundant and varied fauna. Swarms of bats of several species inhabited the mango trees as well as the culverts and manganese mines in the hillsides, and furnished an unfailing supply of material; squirrels, coatimondis,[9] monkeys and marmosets lived in the trees; on the forest floor ranged agoutis,[10] deer and peccaries. Traps left overnight, caught wooly opossums (*Metachirus*), small rodents and giant black lizards that fought viciously when we sought to release them. One of the mammals added to the collection at Urucúm was of unusual interest; it was the formidable *guaraguasú*, a yellow wolf which equals or exceeds in size, the great gray wolf of our own north woods; it is an animal of solitary habits and is so rare that it is seldom met with. It was not previously represented in the American Museum's collection. From the hosts of birds we secured pigmy owls, tinamous, thrushes, grebes, rails and ant birds that were out of the ordinary. We spent nearly three weeks at Urucúm, and each day we added a number of species that were new to us. In the meantime, Colonel Roosevelt and his Brazilian escort had reached Corumbá, and a hunting trip on the Rio Taquary had been planned to secure specimens of the large game that is found in that region.

December 16th found the hunting party aboard the "Nyoac" steaming up the Taquary. This boat had been placed at the disposal of the expedition by the Brazilian government, and was our "home" during the weeks that followed, until we reached Porto Campo. Besides Colonel Roosevelt, there were on board, Colonel Candido Mariano da Silva Rondon, Mr. Kermit Roosevelt, Captain Amilcar de Magalhaes, Mr. Reis the photographer, a physician, a taxidermist and myself. Mr. Cherrie remained at Urucúm to finish the work in that locality, and the commissaries were detained in Corumbá. We reached the landing at the Estate Palmiras just at dusk and spent the night aboard, preparing the skin of a giant anteater which had been shot by Colonel Roosevelt near the river. Early next morning the party was in the saddle, galloping across the grassy marshes. Here and there small clumps of trees and thorny bushes dotted the marshes, and these were teeming with birds of many species: parrots, parrakeets and macaws flashed by with raucous shrieks, and flycatchers calmly surveyed the cavalcade from the uppermost branches. Occasionally we flushed a small flock of teals and, in the distance we saw ibises and jabirus standing in the long grass, like white specks in a sea of green. In spots the marshes were drying, the ground covered with fish; in the small pools an almost solid mass of fishes wriggled in the shallow water which had been churned into thin mud, and at the borders, numbers constantly leapt out; the ground was strewn with the dead and dying myriads of many species.

The ranch house or *fazenda* was reached at noon; it was an interesting place, the long, low rambling buildings forming a square with an open court in the center in which trees and flowers grew, and chickens and pigs roamed at will. All about lay marshes, papyrus swamps, fields and forests. Numerous herds of half-wild cattle grazed on this vast range, and in the papyrus thickets, marsh deer were not uncommon. The main object of this excursion, was the lordly jaguar and a magnificent pair were taken after several all-day hunts. Another giant anteater, several deer and a capybara[11] were collected; also a splendid series of the rare and beautiful hyacinthine macaw was added to our rapidly growing list of treasures.

Returning to Corumbá on the evening of December 24th, we were joined by the other members of the expedition and immediately proceeded on the up-river voyage toward São Luis de Cáceres. A short side trip was made up the Rio São Lourenço, with brief stops at various points where there were evidences of game; and numbers of birds, including screamers, penelopes,[12] parrots and various species of water-fowl were collected, also numbers of small rodents, monkeys, deer and peccaries. The jabiru storks were nesting on the São Lourenço, their great platform nests of sticks perched in the crotch of giant trees. The young storks, two in number and fully feathered, were continually exercising their limbs by running back and forth in the nest, flapping their wings all the while, preparatory to launching forth into the big world.

(*To be continued.*)

[4]Brocket: a small South American deer having unbranched horns.

[5]Cavy: a rodent of South America allied to the guinea pig and capybara.

[6]Tayra: a South American mammal resembling the weasels and martins.

[7]Piranha: the most ferocious small fish in the world, a deadly enemy of man, known as the cannibal fish. It is generally about 12 inches in length.

[8]Anhinga: the American snake-bird.

[9]Coatimondi: also *coatimundi* and more popularly known as *coati*. An American carnivorous quadruped, most nearly related to the raccoon, called also *tejou*.

[10]Agouti: a rodent about the size of the rabbit.

[11]Capybara: the largest existing rodent, resembling the guinea pig.

[12]Penelope: a small South and Central American bird, a small curassow, related to the guan.

Parecis babies at Utiarity.

Progress in Aeronautics*

A Review of Recent Air-raids and What They Have Accomplished

By Major H. Bannerman-Phillips

The first air-raid of any importance against Great Britain occurred in January, and so late in the month that it was impossible to do more than briefly allude to it in these notes, having regard to space available and the exigencies of getting them ready for publishing in time for the monthly issue of the magazine. A review of air-raids in general since the commencement of the present world-war shows that while this attempt of the enemy was apparently conceived on a more ambitious scale than any previous enterprises of a similar kind, the results were small in proportion to the scale of its conception. We may summarize the more important records as follows:

August 30th, 31st, September 1st, 2nd, and 3rd.—Daily visits to Paris by Taube aeroplanes.

September 1st.—Zeppelin airship over Antwerp. Many bombs dropped. Other raids followed with considerable loss of life.

September 4th.—Commander Samson reported bombs dropped on four enemy officers and forty men near Dunkirk.

September 22nd.—Lieutenant Collet and other airmen dropped bombs on Zeppelin sheds at Düsseldorf. Serious damage was done—a distinctly successful raid.

October 8th.—British air-raid over Cologne and Düsseldorf. Zeppelin airships believed to have been destroyed (Lieutenant Marix).

October 11th.—Two German airmen visited Paris and dropped many bombs. Three killed, fourteen wounded.

November 22nd.—Raid on Zeppelin sheds at Friedrichshafen. Much damage done. Squadron-Commander Briggs forced to descend and taken prisoner injured. Results more commensurate with the efforts put forth by our airmen. Most successful.

December 5th.—Enemy aeroplane reported over Dover at 10:55 A. M., but went out to sea again.

December 8th.—French airmen dropped eighteen bombs on Freiburg. To judge from the enemy's published comments, this was most successful.

December 17th-18th.—French airmen dropped bombs on Saarburg, in Lorraine, throwing ten bombs.

December 24th.—German aeroplane flew over Dover and dropped bombs. No damage.

December 25th.—Great British air-raid on Cuxhaven. Commander Hewlett missing, but subsequently found safe. Reports from neutral sources tended to show that both moral and material effects were serious.

December 25th.—German air-raid on England. Bombs dropped near Chatham. Running fight down the Thames as raiders are chased away.

December 26th.—Zeppelin over Nancy at 5:20 A. M. Fourteen bombs dropped. Two people killed. Two injured. Damage to buildings.

December 30th.—Great German raid on Dunkirk. Twenty killed; many injured.

January 3rd.—German newspapers claimed that their airmen dropped bombs on Dover.

January 6th.—Three Zeppelins reported off Calais; no apparent result.

January 10th.—Fifty bombs dropped by Germans on Dunkirk. Many killed and injured. The enemy considered this a distinct success.

The attempt by the enemy's airmen on December 25th appears to have been boldly conceived and carried out with considerable daring. Two airmen in a biplane were sighted on Christmas Day at 12:35 P. M. flying very high east to west over Sheerness. Immediately the enemy was seen anti-aircraft guns opened fire on the invader and three British biplanes went up and gave chase. Two British craft managed to fly above him and fired shot after shot. The fight continued over the Thames estuary to Southend, where there was only one British machine in pursuit. Finally, the German biplane evaded the pursuers and made off toward the sea.

From the fact that the body of a German airman was subsequently found in the Thames, it seems probable that the raiders never returned to report what they had seen or done, so that it is to be presumed that this attempt was a failure. Then came another raid on the night of January 19th-20th. This was directed against Yarmouth and other places on the east coast of England, and judging from the size of bombs found unexploded and other evidence—apart from published German reports, which are not necessarily accurate—was carried out by large naval Zeppelin airships, cigar-shaped craft about 520 feet in length and 50 feet in diameter with a capacity of 750,000 to 1,000,000 cubic feet, of considerable lifting capacity, but very sensitive to weather, more especially to rain or snow, which, lodging on the outer surface of the envelope, is liable to weigh them down. Their great length makes them difficult to handle in a cross-wind. They are fitted with a wireless telegraph installation which will enable them to communicate with ship or shore at a distance of 150 miles. They were originally intended to be fitted with a platform on the upper surface communicating with the central gallery and cars by a well-ladder, the object of this platform being a double one, first to enable observations to be made under more favorable conditions than from the cars, which are, of course, overshadowed by the vast bulk of the dirigible itself, and secondly, to carry machine or other automatic guns for protection against aeroplane attack from above, to which they are most vulnerable. This secondary purpose appears risky in view of the practically inevitable leakage of hydrogen from the gas-containers which, rising to the upper surface and becoming in contact with the air a most inflammable mixture, might easily be ignited by the flash of discharge from the automatic gun or any other fire-arm on the platform. In fact, this has been proved to be the case, and the idea of carrying guns on the latter has apparently had to be abandoned. These vessels can carry explosives in the shape of steel bombs (filled presumably with trinitrotoluol) to a total of two tons in weight. The largest used so far weighs 250 pounds, but the Germans are said to have designed projectiles of 500 pounds in weight for special air-raid purposes, and the crews are, of course, supplied with incendiary and illuminating projectiles in addition to searchlights to enable them to light up any spot on which they may intend to drop projectiles by night. The motive power is usually supplied by Maybach engines, aggregating 500 to 900 horse-power, and they have a possible safe radius of action of 500 miles in a straight line from their protective *hangar*, but their extreme sensitiveness to unfavorable weather conditions appears to have placed very strict limits on oversea voyages. For instance, two are said to have been brought down and sunk during the return voyage from the east coast, according to accounts received from North Sea fishermen. There are sheds capable of sheltering Zeppelin airships at Heigoland (2), Wilhelmshaven, Cuxhaven, Hamburg, and Kiel on the German coast, and at Aix-la-Chapelle (Aachen), Düsseldorf, Cologne (2), Bickendorf, and Treves, near the Rhine and within striking distance of Great Britain. In addition, the Germans are believed to have erected temporary sheds at various points in Belgium, among them Brussels, Antwerp, and Liége.

The Helgoland *hangar*, which is one of the best planned, is double, placed on a pivot so that it can be rotated to face the wind, and so arranged that it can be lowered by hydraulic apparatus into a deep pit in the ground. It is thus safe from attack by warships, unless a shell happens to pitch on it, and presents no mark to aircraft or guns.

The airships which took part in the raid on Yarmouth were apparently three in number, and they subsequently visited other places, including King's Lynn and the neighborhood of Sandringham, Cromer, and Sheringham.

Hostile aircraft were seen at 1:30 P. M. in the afternoon off the Dutch coast. They passed over the island of Terschelling and, crossing the North Sea, reached the English coast after darkness had fallen. Their presence was unsuspected until about 8:30 P. M., when bombs were dropped on Yarmouth. Considerable damage was done, and at least three lives were lost. The bombardment of the town from the air continued for some ten minutes. Several of the missiles did not explode, and one fell through a house in Yarmouth, without injuring the family within. The authorities promptly extinguished the street lights and the people seem as far as possible to have kept under cover. This probably made the death roll lighter than it would otherwise have been. In the darkness, however, it was impossible to distinguish the nature of the craft, which were believed to have carried searchlights.

Commenting on this raid in the *Times* of January 21st, the naval correspondent of that paper said:

"Now that the long-threatened invasion of these islands by Zeppelins has become an accomplished fact, and especially considering the comparatively small amount of damage that has been its result, it is natural to ask ourselves what its object was. Ever since the beginning of the New Year the enemy's aircraft have shown increased activity in several directions, but there has not been conclusive evidence that the Zeppelins have to any large extent taken part in these operations. As a result of the poor part they played in our combined sea and air-raid on Christmas Day there has been a manifest inclination to disparage their ability and to regard their powers as having been much over-rated. This being the case, it would not be surprising if the German authorities were anxious to show that they were capable of doing much more than might have been expected from their performance on that occasion. In other words, the raid was intended to restore their prestige, particularly in Germany, and once more to instill a feeling of apprehension in regard to their menace in this country. This is the most obvious reason for the raid.

"It would be a mistake, however, to accept this as the primary reason for the raid on Tuesday night. The duties of aircraft are scouting and the destruction, by means of bombs, of objects of military usefulness and importance. To these the Germans have added a third, which they term 'frightfulness'—raids which by the murder of non-combatants and the destruction of private property may strike terror into the inhabitants of a country in the hope that, by setting up a state of nervousness, an influence may be exerted on the progress and direction of the war. In our case, of course, the hope evidently is that the flow of reinforcements to the Continent may be stopped, whereas in point of fact the excursion of Tuesday is more likely to have exactly the opposite effect. In almost every case, however, the air-raids of the Germans have served a double purpose. They have combined reconnaissance with bomb-dropping. This last exploit was almost certainly in the nature of a test of the state of our defenses against aerial attack on the east coast if the objective in some future raid is to be a point further inland. The Germans may have obtained some satisfaction, therefore, at finding that the Zeppelins were not brought to action on this occasion.

"In view of the known capabilities of the Zeppelin type of airship, this can only be regarded as a trial trip. Whether there were two or more vessels engaged, they were seen off the Dutch islands a little after noon on Tuesday, and probably left their base half an hour earlier. They arrived over the East Anglian coast at 8:30 P. M., and therefore covered a distance of about 300 miles in little more than eight hours. This would allow them a speed of 36 miles an hour, which is about what they would accomplish at half power. They apparently went back much faster than they came, possibly owing to conditions of wind and weather. As, however, these airships have a radius of action of about 1,200 miles in suitable circumstances, there is hardly any portion of the British Isles that they could not reach, provided they were willing to make part of the journey in daylight. The latest rigid airships are capable of thirty hours' continuous flight at full speed—about 50 miles an hour—or they can do a sixty hours' flight with their engines working half power. Thus, had the vessels used on Tuesday come over at their highest rate of speed, they could have reached almost any of the larger English towns and got back before dawn. As the primary object of the German chiefs is always to lessen the power of the navy, and thus bring about conditions favorable to the use of their own fleet, it might be supposed that vital points like important railway junctions, towns where warlike material is being manufactured, or the big shipyards and arsenals, would be aimed at rather than undefended places like Sheringham and King's Lynn.

"It is fair to assume, therefore, that the Germans had more than one motive in making this air-raid, and that when repeated it will not always be aimed at defenseless towns. There is nothing to prevent the employment of aircraft against points far inland except such precautions as we may take, including the provision of anti-aircraft guns and the darkening of our cities. This defense is partly in the hands of the navy, and so might be also that which is the best defense of all—counter-attack by aircraft. But the Admiralty is not responsible for the protection of the country from everything that flies aloft. It must be pointed out, moreover, that just as it would be suicidal for the Admiralty to alter their naval dispositions and to distribute our naval forces up and down the coast for the ostensible protection of every seaport, so the aircraft we possess must necessarily be concentrated for the protection of the places of national importance

* From the *United Service Magazine*.

which are obviously always open to Zeppelin assault."

The radius of action credited under suitable circumstances to Zeppelin airships in the above comments is a much larger one than the estimate given in the earlier part of this article, namely, 500 miles. It will be interesting to see if the oversea voyages of any airship during the present war should exceed the latter limit.

In a leader on the subject the *Times* remarks that it is significant that in this trial trip no attempt was made to reach London or any spot which might be supposed to possess considerable means of defense against air attack; also that minor reasons for the raid include the pressing necessity for convincing the German people that the Zeppelins are not useless toys. They can hardly be said, after six months of war, to have justified the large expenditure which has been incurred on their behalf. This does not imply that the principle of rigid airships for oversea work is wrong; the amount of capital and energy expended on this particular brand of aeronautics by Germany may have been misdirected, and Great Britain has never taken the airship seriously as a problem to be dealt with summarily and urgently, so that, so far, the investigation has never been carried to a logical conclusion in this country. Germany, previous to the war, had sunk £300,000,000 on her navy, and she must have spent a considerable sum in experimenting on airships, but it would have been far more worth our while to have spent more than she did in order to decide once for ourselves whether anything could be made of such delicate and vulnerable engines of war or whether they could safely be neglected. If they should prove to be of any use at all for oversea reconnaissance, it is logical to assume that they would be of more service to us as the chief maritime power than to the Germans.

In some of the later accounts of the Yarmouth airraid it was stated as a surmise that six Zeppelins took part in the enterprise. As this statement was not based apparently on the accounts of credible eye-witnesses, it probably owes its existence to information furnished by the enemy. Referring to this Mr. T. F. Farman, writing in the *Field* of January 30th, said, in the course of an article on "The Zeppelin Raid":

"If the announcement be true that the Zeppelin raid on Yarmouth and the coast of Norfolk had been carefully prepared, and that after waiting a whole month for propitious atmospherical conditions, six dirigibles—Zeppelins or other types—started from Cuxhaven or Helgoland, or some from each of these places, with the intention of spreading terror in the mind of the British nation. Count Zeppelin must be rather disappointed, in spite of the congratulations he received from the Kaiser and the enthusiasm with which the news of the exploit seems to have been received by the whole German nation. Every civilized man or woman who is not imbued with German 'Kultur' must sincerely regret that a few innocent women and children fell victims to the projectiles dropped from these Zeppelins, and that a certain number of houses were wrecked. However, if the six German dirigibles all reached the English coast, or, indeed, if only two of those airships succeeded in crossing the Channel, the result of their attack was pitiably small in comparison to the extraordinary effort made, the risks incurred, and especially the much vaunted power of destruction of the aerial dreadnoughts. All the evidence which has been forthcoming renders it almost impossible to believe that if six dirigibles started on the murderous expedition they all arrived over the English coast, and if they did not, it would be interesting to know what became of them. Also there is no evidence that even those Zeppelins which dropped the bombs on Yarmouth, Sandringham, etc., returned safely to their sheds, wherever they may be situated. However, as in spite of the telegram from Leyden stating that fishermen saw a dirigible founder in the North Sea, there is at the moment of writing no absolutely convincing evidence to prove the contrary, the whole of the fleet, even if some of the aerial vessels had to turn back before they reached their destination, may have returned without disaster to Germany or to territory occupied by the German army. The weather was most exceptionally favorable for the exploit. The speed of the wind did not exceed 4 or at most 5 mèters a second, that is to say, it was blowing between nine and eleven and a quarter miles an hour.

"From a sporting point of view the voyage of a fleet of six dirigibles across the North Sea from Cuxhaven to Norfolk and its return to Germany undoubtedly is remarkable, but it is far from demonstrating the military value of those vessels. On the contrary, it goes far to prove that if they can act by surprise their pilots are conscious that they must keep out of reach of hostile guns, and above all, avoid giving aeroplanes the chance of sighting them. It will be remarked that after reaching the English shore the dirigibles kept close to the coast, well knowing that if by chance they were pursued by an avion their best chance of escape would be to take to flight over the sea, where they would soon be lost in the mist and darkness, and over which the aeroplane could not follow them for any very long distance without being provided with a specially large tank full of gasoline. Moreover, though the sphere of action of a Zeppelin is very considerable it is not unlimited. Carrying a ton of explosives, it is a very generous estimate to admit that it may be capable of traveling 750 miles, and to effect such a voyage the atmospheric conditions must be most favorable. Cuxhaven is separated from Yarmouth by a distance of about 285 miles, but the Zeppelins which crossed the North Sea hugged the Dutch coast and only steered in a straight line to Norfolk from Ameland Island. It may, therefore, be calculated they traveled some 300 or 310 miles before reaching the English coast. With the return journey the distance covered was between 600 and 620 miles, which approaches the maximum these vessels could travel with any reasonable chance of success. Consequently, even if they had had nothing to fear from fire from the earth or from attacks by British avions, they could not have ventured to extend their voyage as far as London. It is true that dirigibles starting from Belgium would have a shorter distance to cover to reach the British capital, but it is sufficiently considerable to make them hesitate to undertake it except under very propitious conditions, to say nothing of the danger they would run from attack by aeroplanes and fire from the earth or from vessels of war at sea. That the German aeronautical authorities are loath to expose their dirigibles to the attack of avions has been demonstrated by the manner in which they carefully avoid sending them on missions during the execution of which they are likely to encounter any of them."

To return to our chronicle of aerial raids, an official statement by the Admiralty showed that:

"On Friday, January 22nd, twelve or thirteen German aeroplanes appeared over Dunkirk at 11:30 A. M. and dropped bombs.

"No particular damage was done, except that a shed in the docks was set on fire. One of the bombs fell just outside the United States Consulate, breaking all the windows and smashing the furniture.

"Belgian, French, and British naval and military airmen engaged the German aeroplanes, one of which was brought down by a British military machine just over the Belgian frontier. The German aeroplane, pilot, and passenger were captured.

"During the day visits were paid to Zeebrugge by Squadron Commander Richard B. Davies and Flight Lieutenant Richard Peirse. Twenty-seven bombs were dropped on two submarines and on the guns on the mole.

"It is believed that one submarine was damaged considerably, and that many casualties were caused among the guns' crews.

"In making a reconnoitring flight before this attack Squadron Commander Davies was on one occasion surrounded by seven German aeroplanes, but managed to elude them. He was slightly wounded in the thigh on his way to Zeebrugge, but continued his flight, accomplished his mission, and is now progressing satisfactorily."

Then:

"On the 23rd of January a Turkish transport conveying sixteen aeroplanes for the Turkish army in the Caucasus was sunk by a Russian war vessel, and on the 25th of January a German dirigible, while attempting to bombard Libau, was brought down on the Baltic by artillery fire, and was subsequently destroyed and its crew captured."

The vessel in this case was a Parseval. Some interesting details of the raid on Dunkirk were given by the British "Eye-Witness" in the following terms:

"One of our aeroplanes—a single-seater—was on patrol duty, when the observer saw several hostile machines approaching. He at once gave chase to the first hostile machine and opened fire on it. Meanwhile two other British machines started from the ground. It took them some little time to ascend the height of 6,000 feet at which the action in the air was proceeding, during which the British machine which had been on patrol had succeeded in driving off with its fire the two leading German machines. Ten others, however, had come up by the time that the three British machines were all in action. After the Germans had dropped several bombs over the harbor and town the whole turned and flew back toward their lines. Our aeroplanes pursued and brought down one German machine, by a bullet through one of its cylinders. The aeroplane was captured, together with its pilot and observer and eight unexploded bombs. The observer was armed with a double-barreled pistol for firing chain shot. In face of the heavy odds against them this feat on the part of our aviators was distinctly meritorious. The damage done by the raiders was slight."

The last attack by aircraft recorded up to the middle of February was a series of combined aeroplane and seaplane operations which were carried out by our Naval Wing, as announced by the Admiralty on the night of February 12th-13th—"during the last twenty-four hours," the object being to prevent the development of German submarine bases and establishments, and which covered the districts of Zeebrugge, Blankenberghe, and Ostend. According to the official report:

"Thirty-four naval aeroplanes and seaplanes took part.

"Great damage was reported to have been done to Ostend railway station, which, according to present information, has probably been burnt to the ground; the railway station at Blankenberghe was damaged and railway lines were torn up in many places. Bombs were dropped on gun positions at Middlekerke, also on the power station and German mine-sweeping vessels at Zeebrugge, but the damage done was unknown.

"During the attack the machines encountered heavy banks of snow.

"No submarines were seen.

"Flight Commander Grahame-White fell into the sea off Nieuport and was rescued by a French vessel.

"Although exposed to heavy gun-fire from rifles, anti-aircraft guns, mitrailleuses, etc., all pilots returned safely. Two machines were damaged.

"The seaplanes and aeroplanes were under the command of Wing Commander Samson, assisted by Wing Commander Longmore and Squadron Commanders Porte, Courtney, and Rathbone."

This statement is distinctly interesting on account of the attempt at hasty demolition of buildings and objects in connection with the enemy's nerve centers, being on the largest scale up to date to be carried out by heavier-than-air machines. The ascending scale of numbers employed for specifically aggressive purposes in these raids is worthy of note, as well as the extraordinary comparative immunity of both men and craft to damage by the enemy's fire. It is to be hoped that we shall be able to obtain in time some idea of the damage done by our airmen on this occasion.

Equilibrium of the Body*

THE position of the eyes in the fishes and birds indicates that their area of vision without moving the head must be considerably larger than ours, and their sense of equilibrium therefore different. The swimming act is performed by the pectoral fins and telson, while the dorsal and ventral fins regulate the balance of the body, which is to right or left, similar to that of the birds. That the balance is to right or left can be observed with especial ease in the sparrow, which comes in flocks, while on the ground, rushing or fighting for food, the wings are not always entirely extended; frequently one wing is almost resting on the chest for an instant while its mate is stretched to its full length.

In the human body the equilibrium is kept up somewhat differently, being more of a pendulum-like motion, to and fro, when walking on smooth, level ground, the sacrum describes a continuous horizontal wave line, and if a disturbance of balance occurs, the body usually falls forward, seldom to one side.

The oscillaria in the fishes and a few other marine animals can be regarded as annunciators which tell that something is passing outside. Whether the osseous labyrinth in our own ear is of the same character, or not, or whether it is merely an apparatus to aid in preserving equilibrium, is not known with certainty. Neither do we know whether we really see objects in their right position, or only seem to do so through habit, for they must be reflected upside down on the posterior part of the crystal lens of our eye.

Judging from the way pigeons, especially, tip their heads to one side to see where food is thrown on the ground, some lack in their forward vision is indicated and it would therefore seem that seeing the tips of both wings in the same sidewise glance were of more importance than direct forward vision. This ability to see both sides at once is an advantage which aviators do not possess.

Above a flat country, and an altitude of 10,000 feet, or more, the horizon is beneath the aviator and therefore his feelings about the right position of his aeroplane are lessened. Then, too, not passing any object, and being continually met by a strong wind, the airship seems to be standing perfectly still, and this produces a sleepy monotonousness which tends to make the aviator not always on his guard.

LARGE quantities of hydrochlorite of soda are used in the laundry of a large English hospital, where it is found to be effective in destroying micro-organisms and removing stains, without appreciably injuring the fabrics. This solution is prepared on the premises by the electrolysis of a 4 per cent solution of common salt in water. With an expenditure of 10 amperes direct current at 220 volts, twelve gallons of the hydrochlorite solution are produced per hour, which is diluted with nine times its volume of water for use.

*Magnus Westergren in *Science Conspectus*.

Wireless Transmission of Energy—I*

An Explanation of its General Nature and Relationship to Transmission By Wire

By Elihu Thomson

It will be my purpose in the present discourse to outline the general nature of wireless transmission and to indicate its relationship to transmission by wire. It will also be my object to show why the wireless energy sent out follows the curvature of the earth and to explain other features which to many have been more or less puzzling. In short, I desire to present in simple terms a view of the nature of such wireless work, so that anyone reasonably informed about electrical actions can obtain, as it were, a mental picture of the process. I may here state the fact that perhaps one of the earliest experiments bearing on wireless transmission was made in company with Prof. E. J. Houston, while we were both teachers in the Central High School in Philadelphia. This old experiment to which I refer was made about the latter part of 1875, and briefly described in the Franklin Institute *Journal* early in 1876. It consisted in using an induction coil which would give a spark length of several inches, then known as a Ruhmkorff coil, the coil resting on the lecture table, one terminal of the fine wire or secondary of which was connected to a water-pipe ground, while the other was connected by a wire 4 or 5 feet long to a large tin vessel supported on a tall glass jar, insulating the tin vessel from the lecture table. The coil had an automatic interrupter for the primary circuit, and when in operation the terminals of the secondary were approached so that a torrent of white sparks bridged the interval between them, the gap being about 2 inches or so in length. Fig. 1 shows this arrangement. When the coil was worked in this way, it was found that a finely sharpened lead pencil approached to incipient contact with any metallic object, such as door knobs within the room and outside thereof, would cause a tiny spark to appear at the incipient contact between the pencil point and the metal. This, of course, was not a very delicate detector, but was improved, as in Fig. 2, by putting two sharpened points in a dark box, a device due to Edison. One or both points were adjusted so as to make incipient contact, and the tiny spark observed between the points was an indication of a shock, commotion or wave, electrical in its character, in the ether surrounding the tin vessel mounted on the glass jar. The tests for detecting the impulses were carried on not only in rooms on the same floor, but on the floor above and on the floor above that, and finally at the top of the building, some 90 feet away, in the astronomical observatory. Metallic pieces, even unconnected to the ground, would yield tiny sparks, not only in the basement of the building, but in the highest part, with several floors and walls intervening. I mention this old experiment particularly because it has in it the elements, of course in a very crude form, of wireless transmission, the wire and tin vessel attached to one terminal of the coil being a crude antenna with its spark-gap connection to ground, as afterwards used in wireless work by Marconi, and it also shows a rudimentary receiver or detector, a metallic body arranged in connection with a tiny spark gap, so that electrical oscillations in such body would declare themselves by a faint spark at the gap. It was understood by us at the time that after each discharge of the coil there was, as it were, a shock, or wave in the ether consisting of a quick reversed electrical condition, and it was even imagined that there might be in this process the germ of a system of signaling through space. This old work was almost forgotten when it was recalled by the later work of Hertz, about 1887, who demonstrated by suitable electrical apparatus that waves of the general nature of light or heat could be generated, which waves are transmitted with the velocity of light, 186,000 miles per second, and that by suitable resonators or detectors these waves could be made to declare themselves by tiny sparks. The Hertzian oscillator was, as it were, an electrical tuning fork, having an actual rate of vibration peculiar to itself and dependent on its form and dimensions. It was fed with energy from an induction coil and across its spark gap an oscillating discharge took place, which, at each impulse, died out like the discharge of a condenser, but during this discharge it electrically stressed the ether in one and the other senses, so that an electrical wave was radiated in certain directions from the oscillator. It was found that these waves could be refracted, reflected and polarized, and, in general, dealt with as extremely coarse light or heat waves. We shall refer to these, however, farther on. The general result, however, of the Hertzian experiments was to connect electrical waves in the ether surrounding the apparatus with the light and heat waves and prove the identity of the two kinds of radiation, the differences being only those of wave length or pitch.

Fig. 1.

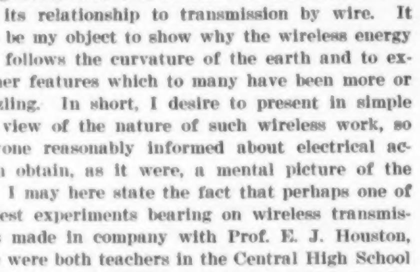


Fig. 2.

Since the Hertzian waves were sent out from the Hertzian oscillator in substantially straight lines, and since in the early days of wireless telegraphy it was common to regard wireless waves as of the same nature or as almost identical with Hertzian waves, the fact that the wireless waves were found to follow the curvature of the earth became a difficulty to be explained. Speaking for myself, I have never found the difficulty to exist. There is really no reason why the waves should not follow the curvature of the earth, as it will be one of my purposes to show. We will, however, approach the conditions of wireless somewhat gradually.

We will first consider an ordinary wire transmission of the simplest type. Let us assume a line of wire, as in Fig. 3, insulated and connected to one terminal of the battery while the other terminal is earthed or grounded. A simple telegraph system on open circuit would represent this arrangement. The only effect is that the battery supplies a small charge to the line, producing a potential difference between the insulated line and the earth, assuming, of course, that there is no leakage of any kind to disturb the conditions. As soon as the charge is established in the line at the full potential of the battery, which, in ordinary cases, would take place within a very small fraction of a second, a steady or static condition is reached, which might be indicated by electrostatic stress lines drawn from the wire to the ground, as illustrated in Fig. 3 by the fine dotted lines connecting the horizontal line to the ground surface below. If the wire be viewed on end (Fig. 4), we must represent these stress lines as extending out radially from the wire and bending over to meet a considerable portion of the ground surface below. As this arrangement is constituted, there is no energy transfer and the condition is static only. If now the far end of the line is earthed, as through an instrument or device which uses energy, as in Fig. 5, at the moment of such connection there would be a lowering of the intensity of the stress toward the receiving instrument and the line would be discharged were it not for the maintaining action of the battery, which still keeps up the difference of potential between line and ground. If the line is without resistance, this potential will have the same value all along the line, especially if the line is of uniform section and of uniform distance from the ground. The moment, however, the instrument at "*I*" takes energy from the line a current is found in the wire and a return in earth, and there is, so to speak, a flow of energy in the space between the wire and the earth and in the ether surrounding the wire, in the direction of the arrow; that is, from the generating end to the receiving end. Surrounding the wire at this time there will be a magnetic field, which may be represented by whorls or lines of magnetism, so called, wrapped around the wire like so many hoops of all sizes (Fig. 6), expanding in size away from the wire in all directions; and a similar magnetic effect, of course, is also produced by the return current in the earth. But, on account of the conditions of conduction in earth being very devious and irregular, it would be difficult to map the magnetism generated. The system of magnetic whorls so developed on the flow of the current in the system reaches, for any definite current, a definite density after a short interval. In other words, the density of the magnetic field between the wire and the earth increases only up to a certain point. If the current, however, be doubled in any way, that field is doubled in density or there are twice as many lines packed in the space around the wire. If now we took instead of an earth-connected circuit one in which there are two wires extending from the generating battery or generator, the conditions will be the same except that the stress lines will now radiate from each wire and connect the wires by lines directly between them and by other curved lines outside. Such lines, or otherwise conceived "tubes of force," represent the static field or the density and directions of electrostatic stresses in the electrostatic field where one wire will be positive while the other is negative. If, as before, the ends of the wires are free or open-circuited, no energy is transmitted, and the mere static stress exists. If, however, the wires are connected through an instrument receiving energy or utilizing the energy, then the magnetic system is developed, surrounding each wire and passing between the wires, and on the establishment of any given current these lines accumulate at a rapid rate until, in a small fraction of a second usually, a limit is reached. The magnetic field may then be said to be fully developed. Outside of the pair of wires the magnetic disturbance extends to very great distances, but is necessarily weak far away. The magnetic whorls in this case do not center themselves in circular paths around the wires and at equal distances therefrom, but between the wires they are more condensed or pushed toward the wires themselves—crowded, so to speak—while outside of the wires they expand (Figs. 8 and 9). It must be remembered that these lines of force are merely symbols for what may be likened to a magnetic atmosphere. They indicate the density and direction of certain actions in the ether, called magnetic. It will be important to note, both in wire and wireless transmission, that the energy is transferred in the surrounding medium. The wire in ordinary wire transmission is, in fact, a sort of guiding center or core around which this ether disturbance carrying the energy exists. The wire may be bent or coiled, expanded or contracted without altering the essential nature of the process. So far, then, ordinary wire transmission is really a case of wireless transmission, with the wire for a guiding core for the energy (Fig. 10).

Fig. 3.

Fig. 4

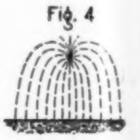


Fig. 5.

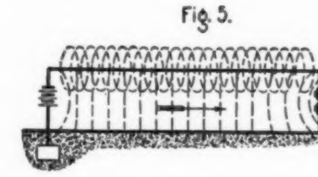
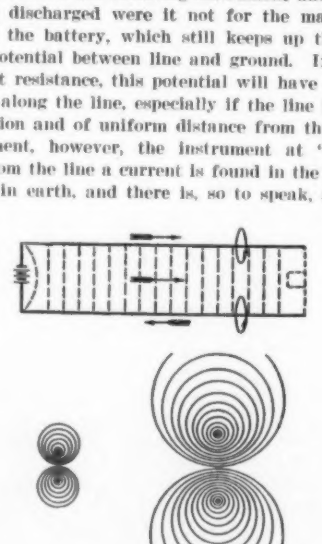


Fig. 6.

It would take us too far to attempt to explain or theorize on the modern view of the passage of electrons in the wire forming the current, and the field they carry with and about them in giving rise to the stresses in the ether surrounding them. Suffice it to say that a moving electron must not only be accompanied or surrounded by the static stress field which it produces in the ether, but also by a magnetic effect representing the energy of motion possessed by it. When a current which has been started in a circuit reaches a definite



Figs. 7, 8 and 9.

* Lecture by Prof. Thomson, printed by permission of the National Electric Light Association, New York, after revision, for the Scientific American Supplement, by the author.

value it may be said to have reached a steady state. It would then be a continuous current of constant value. Energy can be steadily extracted from such a system only by introducing some apparatus connected with the wire which is the guiding core for this energy.

Let us now consider the case of current of a different character, a fluctuating, or better, an alternating current. Let us substitute for the battery an alternating current generator, and assume a single wire with an earth or wire return, as in Figs. 3 and 5. Here the wire merely becomes positive and negative alternately, for the circuit is incomplete or unconnected as a circuit, and the stress lines from wire to earth or to other wires reverse periodically their direction plus to minus and

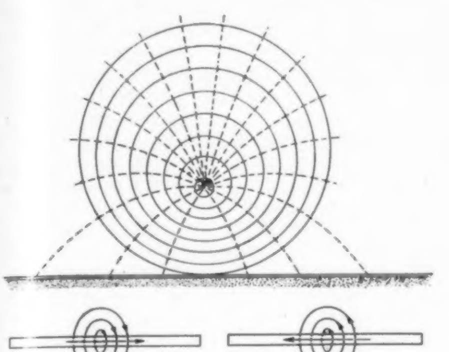


Fig. 10.

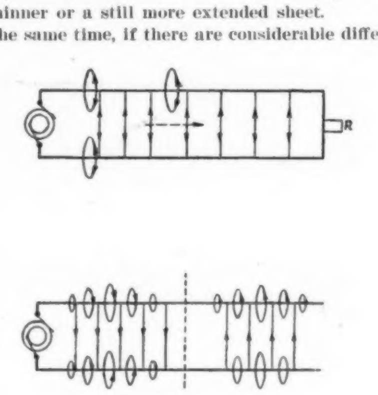
minus to plus. This is true, of course, whether the earth be replaced by a second wire or whether three or more wires be involved, as in a three-phase alternating current circuit. By connecting any two of the wires through an energy-receiving apparatus R (Fig. 11), the same action that takes place with the continuous current may be reproduced except that the energy now comes in waves and is not a continuous flow. In ordinary cases there are sixty complete waves or complete changes from plus to minus and back to plus in each second, and the system is then called one of 60-cycle frequency. A further important difference is to be noted between the alternating-current condition and the continuous. The action in the ether around and between the wires is now in the form of waves, both magnetic and electrostatic. Between wires there is an increase of electrostatic stress to a maximum, a diminution to zero, a reversal, etc. The magnetic field also rises, falls, reverses, and so on synchronously. The condition is no longer static, the medium around the wires is in a dynamic state, and it is now possible to abstract energy steadily from it without actually diverting current from the line. We can, in fact, by such a system produce in neighboring conductors similar disturbances or currents, and along with these disturbances we may deliver energy.

The alternating-current transformer is then merely a device for bringing two or more circuits together as near as possible and enhancing the magnetic values which would normally exist around such circuits by the addition of an iron atmosphere, the iron core, so that the greatest possible transfer of energy from one (the primary circuit) to the other (the secondary circuit) may be accomplished. But in the wire itself, which leads from an alternating-current source, since there is an action called a current which changes, pulsates, or alternates, we have also around the wire core waves in the ether which, in fact, spread to very great distances; some small portion of the energy of each impulse not returning to the system, but passing outward into space as radiated energy.

This radiation may be a very small amount per cycle, especially where the outgoing and return wires are near together and parallel, and with low frequencies, such as 60 cycles, on account of the low number of waves per second and the low speed or rate of change in the fields surrounding the wire, the amount of energy carried off by free radiation into space is indeed negligible. But if we raise the frequency we raise the amount of energy which can be radiated proportionately to the number of waves per second, and we also make the rate of change higher and the wave slopes steeper, so that as the frequency rises the radiation factor becomes more and more important in dissipating the energy of the system. It is diffused through space around the electric system at work and passes off to illimitable distances. Since these impulses in the wire, the electrical waves sent along the wire (with the wire as a guiding core), can at the maximum move with the speed of light —186,000 miles per second—it follows that if the line is sufficiently long or the transmission sufficiently extended or the path of radiation sufficiently distant the wave stresses or fields or currents can exist at different parts of the system in phases either much displaced or entirely opposite. This may be rendered clear by stating that while one portion of a very long line might be positive to earth another portion half a wave-length distant from the first along the same line would be negative to earth (Fig. 12). In other words, there may exist upon the system at the same instant a succession of waves in opposite phase. Just as in vibrating strings in musical instruments or vibrating columns or air in organ pipes there are stationary waves, nodes, and internodes, so in electrical systems in vibration there can be nodes and internodes if the conditions are selected for obtaining that effect. Here the dotted vertical line indicates the nodes of the waves. We may thus have so-called stationary electric waves (Fig. 12).

We find that on raising the frequency of an alternating-current system from, say, 60 cycles, the ordinary frequency, to 600 cycles, an effect which at first was hardly detectable now becomes important. It is the so-called "skin effect" whereby the current in a wire circuit tends to concentrate itself on the outer skin of the conducting wire, neglecting the inner copper, so that the inner core of the wire might be left out. Consider the frequency still further raised, say, to 6,000 cycles, this "skin effect" of the conductor still further increases until the copper in the interior of a circular wire of a considerable size is now quite useless, and to get the advantage of such copper we must, as it were, take it out or spread it in a number of parallel wires spaced apart, or make the metal of the conductor in the form of a long sheet or in the shape of a thin tube or a cage of wires (Fig. 13). This, in electrical terms, improves the conductivity and reduces the opposition due to self-induction; the inductance counter electro-motive force. Let now the frequency be still further increased to tens of thousands or hundreds of thousands of cycles per second; then our conductor must necessarily become a still thinner or a still more extended sheet.

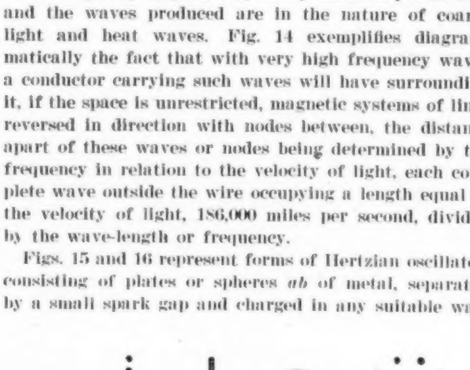
At the same time, if there are considerable differences



Figs. 11 and 12.

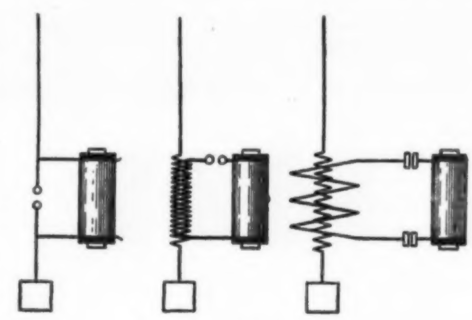
of potential between the conductors thus arranged, the radiation factor may at last become very important, so that if the parts of the circuit are far apart, free radiation into space may dispose of a large fraction of the energy sent out. In the Hertzian oscillator, deducting that lost in the spark gap, practically the whole of the remaining energy supplied is radiated into space. The wave frequency may be very many millions per second, and the waves produced are in the nature of coarse light and heat waves. Fig. 14 exemplifies diagrammatically the fact that with very high frequency waves a conductor carrying such waves will have surrounding it, if the space is unrestricted, magnetic systems of lines reversed in direction with nodes between, the distance apart of these waves or nodes being determined by the frequency in relation to the velocity of light, each complete wave outside the wire occupying a length equal to the velocity of light, 186,000 miles per second, divided by the wave-length or frequency.

Figs. 15 and 16 represent forms of Hertzian oscillator, consisting of plates or spheres ab of metal, separated by a small spark gap and charged in any suitable way,



Figs. 13, 14, 15 and 16.

plus and minus with respect to each other, and allowed to discharge across the gap. The charges are then interchanged between a and b at a very high rate, though the waves decay rapidly, and the system vibrates only for a short time or until the energy of the charge is dissipated in ether waves of exceeding high pitch into the surrounding medium. Were there no energy lost in the gap itself for forming the spark, and if the metal were a perfect conductor, the full amount of energy represented by any initial charge would be dissipated in the ether in these ether waves. Marconi, however, in his development of wireless telegraphy did not use the complete Hertzian oscillator. In setting up his



Figs. 18, 19 and 20.

transmitting antenna he took substantially half an oscillator, the other half being, so to speak, a phantom—the reflected image of the first half, as it were, in the surface of the earth, generally the sea surface. It would be represented by taking an extended copper sheet or surface coated with a fairly good conductor to represent the earth's surface and mounting above it, but insulated from it, a metal body, such as a vertical rod, which could be charged and which could discharge to the sheet through a small air gap. In this arrangement not only would waves be sent out into the surrounding ether space, but there would be current traversing the sheet as waves of current around the spot where the discharge of the insulated body took place. In fact, I think it would be possible to represent experimentally a modern wireless system with a diminutive antenna to represent the transmitting station, and extended copper sheet to represent the earth's surface, and with investigating or receiving antennæ set up here and there or moved from point to point on the extended surface.

Here, although the disturbance and the energy conveyance is in the ether around the antenna (or the part representing the half of the Hertzian oscillator), the energy is guided in its direction by the current in the sheet representing the surface of the sea, just as in the wire transmission the energy is guided by the wire as a core. On account of the enormous extent of the earth's sea surface, there is no need of a return circuit. The energy sent out moves in all directions, guided by the conducting water surface or land surface, as the case may be. There will necessarily be a rapid attenuation of the energy as it leaves the sending or transmitting antenna and spreads out to fill a wider and wider space around it. The higher the sending antenna the greater the distance which can be reached before the attenuation is too great for imparting signals.

Let us consider for a moment by the aid of a figure the actions which must occur in wireless transmission on the sending out of energy from the transmitting antenna. Referring to Fig. 17, we will represent by $e—e$ the surface of the earth as if it were flat, and for moderate distances this will be substantially the case. We will erect on that surface a tall mast A of conducting wire or wires which, at the top, shall have an extension to increase its capacity. This might be a large ball of sheet metal. Usually, for construction to be practicable, it is a set of wires—a sort of cage or a skeleton body. Now, by any system, inductively, conductively, or otherwise, or by what is known as close or loose inductive coupling or what not (Figs. 18, 19, 20) we cause electric disturbances, such that at one instant the top of the antenna becomes positive and at the next instant

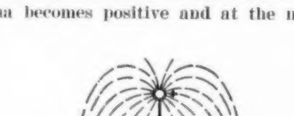


Fig. 17.

negative, many thousands, even hundreds of thousands, of times per second. In other words, we impress a high-frequency wave upon this vertical mast. We will try to present an instantaneous picture or form an instantaneous image of what the condition is at the beginning of the process.

(To be continued.)

The Thomas Military Tractor Biplane

The annexed photograph gives a good idea of the general appearance of the latest military tractor biplane to be constructed for the Government competition, which was held last fall at San Diego. The Thomas military machine has all the up-to-date features required by the Government and even with the 90 horse-power Austro-Daimler motor used, it has shown remarkable speed variation and great climbing ability. With a motor of 150 horse-power, which is what is being used chiefly abroad on military machines nowadays, this machine would be equal to any of those taking part in the present war in Europe.

The wing curve used in the planes of this new machine is that designed and tested by M. Eiffel and found to have the extremely high lift to drift ratio of 1 to 20. Besides this it is particularly adapted to fast climbing with a load, the machine having ascended 4,000 feet in ten minutes (800 feet in the first minute) with pilot, two passengers, and a four hours' supply of fuel. It has also developed a speed of 82 miles per hour when fully loaded and has flown as low as 38 miles per hour. Besides fuel and oil for four hours the machine is figured to carry an additional load of 450 pounds.

The dimensions of this new tractor are 36 feet spread with a 5-foot chord and a 5-foot gap. Its overall length is 26 feet. It is provided with a simple running gear of the two-wheel two-skid type, 26 by 4-inch tires of great resiliency being fitted, the usual rubber band shock absorbers being used as well. Ailerons are fitted to both ends of each plane and are operated either by the usual shoulder yoke or by pedals, according to the usual Thomas practice. The wings are covered with high grade imported Irish linen having a high strength per square inch in both weft and weave. This is sewn on and then treated with 5 to 9 coats of Emaillite. The guys are made of Roebling steel cable, which is doubled for safety, and also nickel-plated wire of the same make is used for some of the minor braces, care being taken to have greater strength in the joints than in the wires themselves. Despite the complete inclosing of the power plant beneath an aluminium bonnet, thus thoroughly protecting same and preserving the stream line form of the fuselage, the motor is easily accessible and can be quickly reached in all its parts, if anything needs attention. Throughout the whole machine accessibility and quick assembling and dissembling of the parts have been the points kept in view in making the design. The struts and wings can be very readily put together or dissembled as the case may be. The factor of safety is seven in every part of the machine. This is, we believe, somewhat higher than is used on many aeroplanes. The machine is a two-seater having aluminium bucket-type seats suitably upholstered and arranged in tandem. On the dashboard in front of the pilot's seat are fitted the usual gasoline pressure gage, revolution counter, inclinometer, barograph, and Pitot tube air speedometer, as well as the switch and gasoline shutoff. The spark of the magneto may also be advanced. The consumption of gasoline with the Austro-Daimler motor is but 9 gallons per hour, while less than one half gallon of oil is used. The mahogany propeller has shown an efficiency of 79 per cent in Eiffel's laboratory test. It, too, has a factor of safety of seven. White ash is used in the construction of the fuselage, all the longitudinal members being of I section and tapered to reduce weight. The struts and cross members are attached by means of steel clips so that no holes are drilled in the longitudinal members. These clips and all the turn buckles, I-bolts, etc., are of steel having a high tensile strength. Following is a table of the requirements made by the army and the actual performance of the new Thomas tractor. The weight of this new machine empty is approximately 1,075 pounds.

U. S. ARMY REQUIREMENTS.

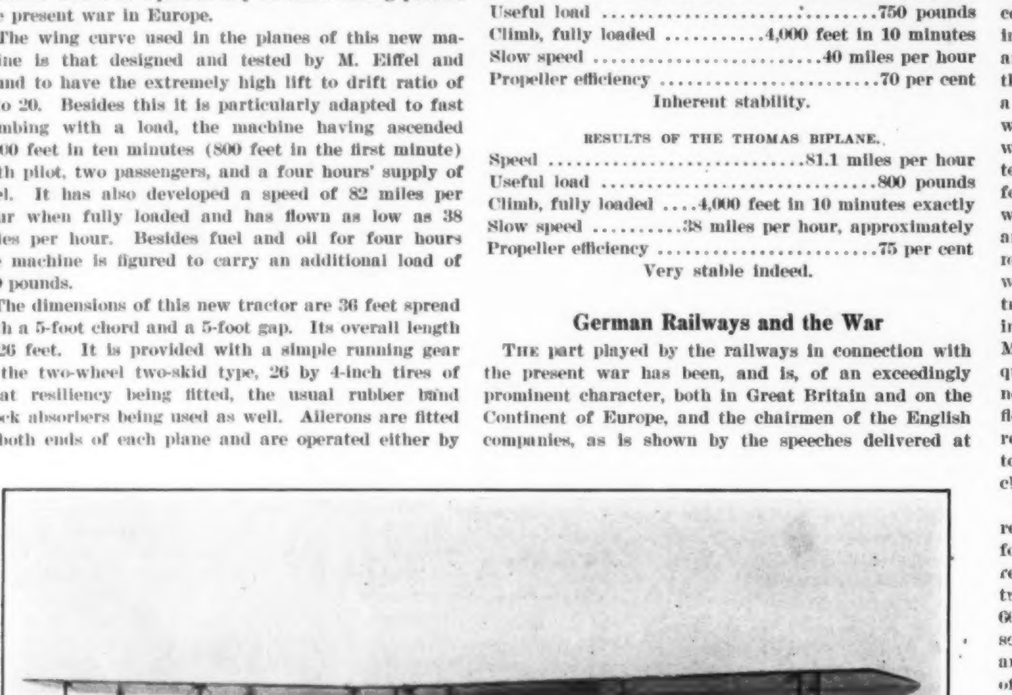
Speed	70 miles per hour
Useful load	750 pounds
Climb, fully loaded	4,000 feet in 10 minutes
Slow speed	40 miles per hour
Propeller efficiency	70 per cent

Inherent stability.

RESULTS OF THE THOMAS BIPLANE.

Speed	81.1 miles per hour
Useful load	800 pounds
Climb, fully loaded	4,000 feet in 10 minutes exactly
Slow speed	38 miles per hour, approximately
Propeller efficiency	75 per cent

Very stable indeed.



The Thomas military biplane.

German Railways and the War

The part played by the railways in connection with the present war has been, and is, of an exceedingly prominent character, both in Great Britain and on the Continent of Europe, and the chairmen of the English companies, as is shown by the speeches delivered at the annual meetings which are now in progress, are, naturally, congratulating the shareholders on the smoothness with which working has proceeded notwithstanding the temporary congestion of traffic since the outbreak of the war, under the administration of the executive committee of the general managers acting under the directions of the Board of Trade.

It may be instructive to investigate the economic effects which have been brought about in the working of the German railway system since the outbreak of hostilities, as is set forth in the newspapers published in that country. According to the figures issued by the State Railway authorities at the end of January, an enormous decline took place in the receipts from the goods traffic on the Prussian railways in the month of August, including receipts charged for military transport purposes, although a progressive improvement ensued in each succeeding month to the end of the year. The receipts in August, for instance, are returned at 41.25 per cent of the receipts from goods traffic in the equivalent month in 1913; in September, 68.73 per cent; October, 79.67 per cent; and November, 81.41 per cent; while for December, as was announced by the Prussian Minister of Finance in the Prussian Diet on February 9th, the receipts amounted to 95 per cent of those realized in the same month of 1913. If the figures can be relied upon as being accurate, the decline which took place in the opening months of the war must be considered to be small; the reduction, indeed, is said to be even less than what occurs in an ordinary period of receding commercial prosperity. As the production in many branches of trade, as, for instance, coal mining, iron and steel manufacture, etc., has been, and still is, largely restricted in consequence of the comparative scarcity of labor, it is assumed that important displacements in traffic have occurred by the railway transport of commodities which were formerly conveyed by waterway or sea route from the east to the west of the country. In the case of the passenger service on the Prussian railways, including troop trains, the financial results have been proportionately more unfavorable than those derived from the goods service. As compared with the equivalent months in 1913, the receipts from the passenger traffic are recorded at 56.51 per cent in August, 49.59 per cent in September, 61.80 per cent in October, 75.36 per cent in November, and 68.1 per cent in December. It is calculated that the reduction in the receipts from the goods traffic in 1914 has amounted to £13,000,000 ($65,000,000), and that from the passenger traffic to £6,500,000 ($32,500,000), making a total decline of £19,500,000 ($97,500,000) as compared with the preceding year, when the combined receipts were £163,000,000 ($815,000,000). The Prussian Minister of Finance, in the course of a speech delivered before the Lower House on February 9th, stated that while the railways solely served the purpose of goods and passenger traffic in times of peace, they were a mighty and important instrument in the conduct of war. In announcing that the receipts from the goods traffic in December had risen to 95 per cent of the total in the same month in 1913, as previously mentioned, the Minister remarked that the development was an eloquent indication of the great extent to which the economic life of the country was again pulsating and again flourishing. The proportion of working expenses to receipts had increased, but any deficiency was expected to be met out of the equalization fund, which was declared to exceed £16,000,000 ($80,000,000).

If the German figures concerning the percentages of receipts are trustworthy and have not been prepared for public consumption, they certainly show remarkable results under the conditions which prevail in that country. The coal industry, for instance, is only working at 60 per cent of the normal output and a comparative scarcity of coal exists, while the production of the iron and steel trades is only about an average of 50 per cent of the normal rate. But as the export trade in coal and iron and steel is insignificant at the present time, nearly the whole of the output is being absorbed by the home market. With the limitation in other industries it seems incredible that the goods traffic could have reached in December within 5 per cent of the receipts which were earned in the corresponding month in 1913, and the German statement may therefore be accepted with considerable reserve. At the same time, there is less reason for doubting the assertions that the German State Railway authorities have in operation seven Russian, nineteen Belgian, and three French railways, in the working of which 42,000 Germans are employed, and that the sole object of the invasion of Russian Poland in September and November was the destruction of railways and roads which might be of service for the Russian army.—*The Engineer.*

The Schumann Region of the Spectrum

Between the shortest Schumann waves and the waves of the X-rays there is at present a gap in which the relation between light and matter undergoes a profound change, and while further exploration of the region would undoubtedly reveal results of the greatest value, the difficulties in the way are enormous. Still with the knowledge of other difficulties, apparently fully as great, that have been successfully overcome by scientific investigators, it would not be safe to say that anything is impossible. Indeed, a considerable step has already been made in the desired direction by Dr. T. Lyman, who has succeeded in photographing the spectrum to wave-length 905, which is really a greater advance than Schumann accomplished, in view of the continually increasing difficulties, and an account of this work is given in "The Spectroscope of the Extreme Ultra-Violet," published by Longmans, Green & Co. London.

A most interesting portion of this work is the description of the apparatus employed. The opacity of air, glass, and quartz to the Schumann rays renders it necessary that the entire spectrograph and source of light should be inclosed in a vacuum, and that special materials should be used for the construction of lenses and prisms; specially prepared photographic plates are also necessary. Schumann made use of a vacuum spectrograph having prisms and lenses of fluorite, but Prof. Lyman has employed a concave grating of one meter radius, which is much simpler in adjustment and has the great advantage of permitting the determination of wave-lengths.

Prof. Lyman also discusses the absorption of many gases and materials in the region of short wave-lengths, as well as the spectra of various elements. The work will be found indispensable to those who propose investigations in the ultra Schumann region.

The Uses of Light in the Treatment of Disease*

Its Value as an Efficient Remedy When Properly Employed

By E. C. Titus

From time immemorial the beneficial influence of sunlight upon animal and vegetable life has been recognized, but it is only at the present time that we are appreciating its full value in the treatment of disease.

The excellent and even wonderful results of heliotherapy in the treatment of bone tuberculosis, to which attention has been called within a recent period, will serve as an illustration.

For obvious reasons, however, sunlight is not always available, and it has therefore been found advantageous to resort to other sources of light. Thanks to the progress made in electricity, we now have at our disposal various means of obtaining light closely approaching that of the sun in its remedial action, and to these means, chiefly, my paper will be devoted.

It must be remembered that the thermic effects of light are due to the impingement of the rays upon the translucent cutaneous tissues. The arrest of the light ray by the skin and subcutaneous structures produces radiant heat which has a higher penetrating power than convection heat as generated by a hotwater bag or poultice, for instance. It has been found that the thermic effects of light extend to a depth of two inches or more, while convection heat is principally exerted upon the surface. In comparing the therapeutic action of both it will be seen that the changes produced in the tissues by the former are much more pronounced. Thus if the body be exposed to an intense light, as in an electric light cabinet bath, the resulting hyperemia and elimination of waste products by the skin and kidneys (cellular nutrition) are much more pronounced than in a Turkish or Russian bath. The marked augmentation of the oxidation processes in the tissues is shown by the greater amount of carbon dioxide thrown off by the lungs and by the increase of solids in the urine. It is also claimed that the natural defences of the body (phagocytosis) are greatly promoted.

The actinic or chemical rays play an important part in phototherapy only when the light is concentrated upon a localized area as in the use of the arc lamp. Under these circumstances the actinic rays appear to enhance as well as modify the action of the thermic and luminous rays. Thus the ultra-violet radiations, which are actinic, have been shown to exert an anti-bacterial action as well as to promote local phagocytosis.

The general application of phototherapy consists practically in the use of the electric light bath, and since much of the benefit to be derived from this agent will depend upon the apparatus employed, I will first give a description of what has proven to me to be the most satisfactory type of cabinet.

An electric light cabinet should be constructed according to the following plan: The cabinet should be octagonal in shape, 4 feet square by 5 feet high; the lining should be of white blotter and not mirror surface; the source of light should come from 100 40-watt tungsten lamps, conveniently arranged, so that they will be under control from within by properly placed switches, one half or full number of the lamps to be employed, as desired. The cabinet should open at the top, not entirely, but partly so and it should have an air vent 3 inches in diameter in the center of the floor, over which is placed a low stool 18 inches high, upon which the subject is seated. (It has been found that a ventilated room is much more quickly and evenly heated artificially than one that is closed or sealed.) The further advantages of this construction are that a large volume of light with a minimum amount of heat is produced in the cabinet, that the emanations of noxious gases and odors from the human body are quickly carried off, that the degree of cutaneous hyperemia and diaphoresis is much more intense, and that the usual depression and other unpleasant symptoms are entirely obviated, as compared with the older form of closed cabinet.

Among the conditions in which the electric light bath has proved to be most serviceable are arteriosclerosis (hardening of the arteries), gouty and rheumatic conditions, Bright's disease, diabetes, obesity and acute catarrhal affections of the respiratory tract.

In the majority of cases of arteriosclerosis in the earlier stages I have advised the regular use of these baths with beneficial results, and I firmly believe that they have warded off more serious organic changes which otherwise frequently ensue.

The effects of these baths are:

1. To induce intense hyperemia or reddening of the skin and thus reduce the congestion of the deeper organs, which is frequently present.

2. To increase elimination by way of the lungs and skin. It has been found that during and following the bath the elimination of carbon dioxid is practically doubled, while the profuse perspiration produced carries away much toxic or poisonous material and in that way relieves the overtaxed kidneys. As it is generally accepted that toxemia plays an important part in the causation of hardening of the arteries, the benefit to be derived from this method is readily apparent.

Rheumatic and Gouty Affections—In late years it has been frequently pointed out that many conditions commonly termed rheumatic differ essentially from the acute type of the disease which is very probably of bacterial origin. On the other hand, there is abundant reason to believe that these chronic forms which have been grouped under the names of rheumatoid arthritis, rheumatic gout, osteo-arthritis, arthritis deformans, are the result of auto-intoxication and disturbances of metabolism. From what has been said above it will be readily understood that the marked effect of the electric light bath in increasing elimination will exert a beneficial influence upon the toxemia in these cases and therefore prove ot material aid to other treatment. The distressing pains and stiffness in the joints are also greatly relieved as patients have frequently assured me. In chronic gout, which is more frequent in this country than is generally thought, the action of light baths is to augment the cutaneous or peripheral circulation and in that way favor the absorption of uratic or chalky deposits.

It may be asked why a Turkish or Russian bath will not do equally well in the conditions mentioned. My own experience has shown that the effect of the light bath is much more pronounced and prolonged.

Bright's Disease.—One of the chief aims in the treatment of Bright's disease is to lessen the work of the kidneys. The light bath will be found a better auxiliary measure for accomplishing this purpose than the usual hot pack or steam bath. As previously pointed out, notwithstanding the profuse sweating induced, the patient experiences no depression because of the stimulating effect of the light energy upon the peripheral nerves.

Diabetes.—The light baths are not adapted to every case of this disease, but particularly to patients who present a dry skin with various cutaneous eruptions, especially of an eczematous character. The best results are obtained where diabetes is attended with high blood pressure.

Obesity.—The heat penetration in an electric light bath which, as already mentioned, extends to a depth of over two inches, stimulates the oxidation processes in the fatty tissues and promotes their disintegration in cases of obesity. It will thus prove an excellent auxiliary to the customary treatment.

Acute Catarrhal Affections of the Respiratory Tract.—The writer has frequently had an opportunity to witness the beneficial effects of an electric light bath at the beginning of a cold in aborting it or greatly ameliorating its course. From personal experiences there can be no question of its superiority over the customary hot bath and diaphoretic (perspiration inducing) remedies.

In the local applications of light the following means are available:

1. The arc light, which is best employed by means of an ordinary marine searchlight, with its glass front window removed. The one I employ consumes 25 to 35 amperes of direct current at 40 volts, and projects the light in parallel rays by means of a 12-inch parabolic reflector, and has a light value of about 5,000 candle-power.

2. The high power incandescent lamp with a carbon or tungsten filament of 500 candle-power and provided with a dome reflector. The carbon filament uses 12 amperes at 110 volts, while the tungsten lamp consumes only 3 amperes at 110 volts. The former gives off more thermic rays, while the latter produces a greater amount of white light with a minimum amount of heat.

As already mentioned in discussing the general applications of light, it constitutes a means of generating heat within the tissues down to a depth of two inches or more, while convective heat is far less penetrating. Moreover, besides the conversion of light rays into heat, we have to deal with the chemical actinic rays which also play a not unimportant part in phototherapy.

The sum total of the combined effects is as follows. There is an increased local activity, as manifested by a pronounced hyperemia and an augmented tissue oxidation and elimination. The effects of radiant energy, however, are not confined to the site of application, but are so diffused that remote effects are produced in distant organs and nerve centers as a result of peripheral or cutaneous stimulation. It is easy to understand that the increased circulation, oxidation and elimination in the affected part will relieve congestion and promote absorption of exudates and deposits and the excretion of toxic materials. It has likewise been shown by physiological investigators that the heat production in the tissues increases phagocytosis and thus enhances the vital resistance.

The rapid relief of pain and local spasm experienced from light therapy is due in a great measure to the reduction of congestion and to tissue relaxation. In this connection it may be emphasized that these decided effects are brought about without the least risk to the patient, a statement which is not applicable unreservedly to other methods of treatment.

The employment of the parallel rays from a high power marine searchlight as described above, applied for 30 minutes to the spine at a distance of 10 feet, is one of the most effectual and lasting means of relieving many forms of spinal congestion.

In the acute stages of bronchitis or in pulmonary congestion from almost any cause, light applications to the chest afford a more prompt relief of chest pain and respiratory distress than any other measure with which I am familiar. In cases of chronic bronchitis marked benefit is obtained by prolonged daily applications of light to the front and back of the chest, continued until marked redness and tanning of the skin is produced.

To promote more speedy absorption in pleurisy I know of no better means than the daily use of phototherapy. In lobar and bronchial pneumonia its beneficial influence is manifested by marked relief of pain and dyspnea (shortness of breath) and an improvement in the general comfort of the patient; and in cases where resolution was delayed, it seemed to hasten this process.

I have frequently had occasion to resort to this treatment, using either the arc or 500 candle-power tungsten lamp, in cases of both acute and sub-acute inflammation of the gallbladder, congestion of the liver and other abdominal viscera from chronic malaria, alcoholism and persistent intestinal auto-intoxication. It is no exaggeration to say that my results have been far better than when sole reliance was placed upon customary medicinal treatment.

In the treatment of muscular rheumatism, neuritis and even the intense discomfort associated with herpes zoster (shingles), more rapid and lasting relief, due to diminished congestion and nerve sensibility, will be obtained by this method than by recourse to the various analgesics and with no risk of undesirable after-effects.

The pain in acute middle ear catarrh (common earache), the frontal or orbital headache accompanying acute colds, and especially involvement of the frontal sinus and ethmoid cells is promptly alleviated by a thorough application at frequent intervals of light from a 50-candle power carbon or tungsten lamp in a suitable reflector. To this I can testify not only from my own experience, but I could add the testimony of many physicians familiar with the use of this potent therapeutic agent. In chronic ear trouble and disease of the frontal sinus and antrum, it has proved a very valuable auxiliary by relieving the congestion and clearing up the discharge.

It has been my privilege to witness the success of this treatment in several cases of catarrhal appendicitis, and it has seemed to me that the pain and other symptoms were more quickly ameliorated and the necessity of surgical intervention more often avoided than had been my previous experience.

In various types of septic conditions, such as phlebitis, so-called milk-leg, following child birth, or intrapelvic operations, the use of light in the manner indicated or by means of the multiple light dome, as employed in the Women's Hospital in New York, has proved a well-nigh indispensable agent in gynecological practice.

It will be found equally useful in the treatment of infected wounds of the extremities, cellulitis, furuncles, varicose ulcers, and localized infective processes in general.

From experience up to date there seems to be a brilliant future for this measure in hastening repair in cases of delayed union of fractures.

In an article published some time ago I reported observations which showed that it might be possible to prevent the occasional deleterious effects of the X-ray by following its application with the rays from a marine searchlight. It is very gratifying to me to state that subsequent experience has seemed to confirm these results.

*A paper read at the eighth annual convention of the Illuminating Engineering Society, Cleveland, O., September 21st-24th, 1914, and published in the *Transactions*.

NEW BOOKS, ETC.

OUR NAVY AND THE NEXT WAR. By Robert Wilden Neeser. New York: Charles Scribner's Sons, 1915. 12mo.; 205 pp. Price, $1 net.

Here is a timely work, which, after careful perusal, we most cordially recommend. The author sets forth the present conditions in our navy, points out its deficiencies, shows the directions in which it should be improved and strengthened both in material, personnel and administration, and closes by giving the general recommendations of the General Board of the Navy made to the last Congress. Mr. Neeser is admirably qualified for the task which he has performed so well in this volume. An enthusiast on naval matters, he is possessed of probably one of the finest private naval libraries in the world. He is thoroughly familiar, not merely with existing conditions in the navy, but with the whole of its thrilling history from the date of its foundation. To this he adds the advantage of an unusually lucid and forceful literary style—too often lacking in modern literature—and largely to this fact is to be attributed the charm and interest which holds the reader's attention closely throughout the volume.

Particularly forceful and greatly needed in the present hour is that portion of the book which is devoted to showing the relation of naval power to national policies—a subject upon which the American citizen, and particularly his representative in Congress, needs to be very thoroughly instructed. There is doubtless a growing feeling throughout the country that, although we have some very fine ships manned by efficient and enthusiastic seamen and commanded by officers second to none in their profession, there is yet something very seriously wrong with our navy. Mr. Neeser points out with great lucidity and strong emphasis just what the troubles are and where they lie. At the present time when there is such widespread interest in the subject of our defense, his work will serve admirably as a textbook and reference book for schools, colleges, debating societies, writers and speakers who are seeking for definite information on a subject of vast national importance.

INDOOR GAMES FOR CHILDREN. Written and illustrated by Gladys Beattie Crozier. London and New York: George Routledge & Sons. 16mo.; 120 pp.

This is a delightful book for children, illustrated from actual photographs showing children playing the games. We find such interesting chapters as: An Impromptu Nursery or Schoolroom Masquerade, including Santa Claus, a Scarecrow, a Cowboy, a Fireman, Peter Pan, Charity Girl, Cave Man, a Spook, Pirates, a Dunce, King Henry V., Brunhilda. While the book is an English one, the games can be played anywhere by children irrespective of nationality. The chapter devoted to "Living Statuary Tableaux" is an excellent one. It is a book which will be welcomed by all children.

NATHAN HALE, 1776. By Henry Phelps Johnston, Professor of History in the College of the City of New York. New Haven: Yale University Press, 1914. 8vo.; 296 pp.; illustrated. Price, $2.35 net.

Of Hale's correspondence and papers there are known to exist about 70 pieces, of which 64 are represented in this enlarged edition of Henry Phelps Johnston's work. Ten of these are letters written by Hale himself. His home and his ancestry, his four years at Yale, and his experience as schoolmaster, bring us to the Lexington alarm. There are vivid glimpses of camp life and of engagements with the enemy. Hale's movements in that desperate enterprise within the British lines are for the most part shrouded in the secrecy such enterprises demand, but the author allows himself some interesting and plausible conjectures. Then there flashes before us that sinister announcement from the British Commander-in-Chief—a spy executed, and that spy Hale. The latter half of Prof. Johnston's history deals with the preservation of the patriot's memory, the substantiation of places and sites of importance, his alleged betrayal, and the correspondence and papers before mentioned. Altogether the volume is a fitting resuscitation and embodiment of those memories that once were the man who "would have made a soldier after Cromwell's own heart—an Ironside who could pray mightily and fight as he prayed."

LEHRBUCH DER METEOROLOGIE. Von Dr. Julius von Hann, Professor an der Universität Wien. Dritte, unter Mitwirkung von Professor Dr. R. Süring, Potsdam, umgearbeitete Auflage. Mit 28 Tafeln und 4 Tabellen, sowie 108 Abbildungen im Texte. Leipzig: Verlag von Chr. Herm. Tauchnitz, 1915. 4to.; xiv, 847 pp. Price, 36 marks.

The third edition of Hann's great "Lehrbuch" has been appearing in parts since January, 1914, and is now complete. Thus the misgivings that most meterologists must have entertained as to the possible effect of the European war upon the later stages of this book's production are now happily dissipated. Julius Hann, although chiefly a collector and digestor of other men's work rather than an original thinker, undoubtedly occupies the most prominent place among living meteorologists. His "Lehrbuch" is the work to which every meteorologist instinctively turns in order to ascertain the state of contemporary opinion upon any question relating to the atmosphere. Whereas the average scientific textbook gives the impression that the science of which it treats is in a more or less "finished" condition, Hann presents a true picture of meteorology as a body of knowledge in the making—bristling with unsettled questions, the various tentative answers to which are submitted to the reader, together with copious references to fuller discussion of these mooted points in other books and the scientific journals. This work is, therefore, above all a bibliography—but a most carefully selected and arranged bibliography and collection of abstracts, constituting a "short cut" to the contents of a meteorological library. The first edition of the "Lehrbuch" was published in 1901, and a second, somewhat more condensed in order to make it more convenient for use in the class-room, in 1906. The third edition, we are glad to note, reverts to the scope of the first, which it exceeds in size by about 40 pages. That this work demands prompt notice in the SCIENTIFIC AMERICAN SUPPLEMENT and journals addressed primarily to specialists in meteorology and kindred sciences, is due to the fact that every well-regulated library, personal or otherwise, ought to include at least *one* general treatise on atmospheric phenomena; and, provided its language is not a barrier, Hann's "Lehrbuch" is undoubtedly the book to be selected; just as the same author's "Handbuch der Klimatologie," a third edition of which, in three volumes, was published in 1908-1911, has no serious competitor for first place among general works on climatology and climatography. As to the language, it may be said that persons of English speech find Hann's German exceptionally easy. The collaboration of Dr. Süring, who is Hann's colleague in the editorship of the *Meteorologische Zeitschrift*, has strengthened the portions of the work dealing with the rapidly expanding subjects of aerology (upper-air research) and atmospheric electricity, and also the section on the forms of clouds. Typographically the book is as admirable as the average German textbook. Hann's Meteorology has one serious fault, which it shares with his Climatology; it is quite inadequately indexed. In this respect it is almost as bad as some of the best scientific books emanating from France. However, copiously and rationally indexed books are so rare, in any language, that they may be regarded as bibliographic curiosities.

REPTILES AND BATRACHIANS. By E. G. Boulenger, F.Z.S., Curator of Lower Vertebrates in the Gardens of the Zoological Society. New York: E. P. Dutton & Co. 8vo.; 278 pp.; illustrated. Price, $6 net.

Mr. Boulenger's work offers a delightful browsing ground to the naturalist. The reptilian section of the London Zoological Gardens is unsurpassed, and its curator is as fortunate in his environment as the Zoological Society is in its curator. In his comprehensive volume, "Reptiles and Batrachians," Mr. Boulenger discloses to us the treasures under his charge; but instead of leaving us to wander blindly and for the most part fruitlessly among these zoological wonders, we have as guide none other than the distinguished curator himself. Under his tutelage we pursue a well-planned itinerary, and gain more than a glimpse into the classification, the inter-relationships, of the animals we study. Their life histories and their habits are briefly but most interestingly related by our guide, while the photographical skill of Mr. W. S. Berridge, F.Z.S., has resulted in placing before our eyes a wealth of reptilian life in characteristic attitudes and occupations. Infinite patience and great skill must have been the price paid for many of these splendid pictures. As instances we may cite grass snakes emerging from their eggs, the frilled lizard with mouth agape and collar expanded, and a reticulated python, giant of all snakes, in the act of constricting a kid. The skill of author and illustrator, combined with their unusual opportunities for study, has given us a most instructive and beautiful volume.

THE YEARBOOK OF WIRELESS TELEGRAPHY AND TELEPHONY. 1914. New York: Marconi Publishing Corporation.

Although a house publication of the Marconi Company and therefore in a certain sense a piece of advertising literature, the Yearbook of Wireless Telegraphy is of value. As might be expected, however, the historical portions not only give the full credit to Mr. Marconi which he deserves, but also fail to mention adequately the work of other pioneers. Thus only the dates of Prof. Herz's birth and death are given. Prof. Slaby is little more than mentioned. In chronicling the award of the Nobel Prize to Mr. Marconi in 1909, it is not stated that the prize was divided between Mr. Marconi and Prof. Braun, although the fact is brought out in the biographical notices, in a five-line item. Particularly good is the compilation of the wireless laws of the various countries. A list of wireless telegraph stations is given, but nothing is said about the systems used. Prof. Fleming has a very fine article on electric measurements in which he discusses some of his own contributions to the art. R. Hinks of Cambridge writes very instructively on wireless time signaling and lays particular stress upon the importance of this service in countries sparsely populated. C. E. Prince describes the application of the radio-goniometer of Bellin and Tosi in the construction of the Marconi compass. The origin of the Marconi C.Q.D. signal is explained by G. E. Turnbull. The wonderful effect of wireless telegraphy in making marine navigation safer is well brought out in another article. A. Gray presents an excellent picture of the development of the Marconi system. A good article is that of R. Sankey in which he explains the physical basis of wireless telegraphy by mechanical processes. It is an article that will make clear much that is now mysterious to the non-technical reader. The work of Prof. Slaby in introducing the principle of resonance in wireless telegraphy is not sufficiently acknowledged in the article on resonance. Erskine-Murray gives a very good review of the present status of wireless telephony. G. Kindersley discusses the development of the wireless transmitter. Of particular interest at the present time is the article on wireless telegraphy for war purposes. Dr. H. Eccles, whose writings on wireless are well known to all amateurs, shows what has been done in long distance transmission. G. Prince gives a fairly good account of the production of continuous waves. It is curious, however, that Prof. Wien should appear as Prof. Wein, which must be more than a mere typographical error, since the name is mispelled more than once. A rather dark reference is made to a new device of Marconi's for producing continuous waves mechanically in ocean wireless telegraphy; no description is given of the method. Slaby's name is not mentioned in the biographical notices. As might be expected, Marconi receives the maximum space of 184 lines. He deserves it. Still, one cannot but help regretting that an annual which is so extremely useful could not be made more useful by being less one-sided.

CARRANZA AND MEXICO. By Carlo de Fornaro. With Chapters by Col. I. C. Enriques, Charles Ferguson and M. C. Rolland. New York: Mitchell Kennerley, 1915. 12mo.; 242 pp.; with illustrations and map. Price, $1.25 net.

Don Venustiano Carranza has the distinction of being the only man to revolt successfully against Gen. Diaz; he won his cause and outlived the Diaz administration, to perform, at the age of fifty-five, feats of endurance and valor in behalf of the fifteen million peons who attacked Huerta and his "governmental camorra." The life of Carranza and the complicated problem of Mexico is skillfully unfolded by the author, who makes no concealment of his detestation of Diaz and his "Machiavellian talent." He charges that "great newspaper proprietors in the United States were given concessions" and "offered special inducements" to create a favorable sentiment in behalf of Diaz and his government. In these charges he is not sufficiently specific, but in general his allegations are at least circumstantially set forth. All interested in visualizing the ingredients of the Mexican imbroglio should read his version of conditions behind the scenes. His work has the hall-mark of sincerity, and such fervor as it possesses is not allowed to befog the clearly sketched, cumulative details of the narration.

THE FUTURE OF WORLD PEACE. A Book of Charts Showing Facts which Must Be Recognized in Future Plans for Peace. By Roger W. Babson. Boston: Babson's Statistical Organization (Incorporated), 1915. Price, $1.

The director-in-chief of the World Peace Foundation favorably discusses this volume, but wishes that the section dealing with "The Danger of the United States" had been suppressed. It would, on the contrary, be well if this section had been made into a tract and distributed broadcast throughout the land. It is one of the most succinct, sledge-hammer arraignments of our invertebrate national defense that we have seen. The main portion of Mr. Babson's striking work proposes a commercial international federation, an extension of the Hague Court, whose primary object would be the neutralization of trade routes. He suggests that the strength of a nation's representation in this affiliation be based upon its "fundamental fighting strength," as determined solely by its number of adult males able to read and write. The objections to this criterion are so obvious and so overwhelming that it is unnecessary to cite them. The physical culturist on the one hand, and the psychologist on the other, may be depended upon to make their protests heard. The suffragists, the socialists and the progressives will object to a course that would abolish war only to substitute cancerous intrigue; and finally the United States as a whole would reject a classification that listed them as third in this commercial federation, even if the United Kingdom had no objection to being relegated to fourth place. However, these criticisms apply only to the suggested plan of representation, and not to the central idea. As a whole, Mr. Babson's work is keen, clear-visioned, and most instructive as to present actual conditions. His charts place both comforting and discomforting facts bluntly before the reader, and his tractate adequately opens up a question that must slowly proceed to a solution, if not to the author's solution.

DRAKE'S TELEPHONE HANDBOOK. A Book for the Practical Man. By David Penn Moreton, B.S., E.E. Chicago: Frederick J. Drake & Co., 1915. 16mo.; 286 pp.; illustrated.

The ten chapters of this manual carry much solid information for the practical man. They undertake to explain electromagnetism, alternating current, the measurement of resistance and capacity, magneto and common-battery systems, and line construction. A chapter on sound is included in order that the student, by understanding its basic qualities, may the better appreciate the problem of the telephone engineer. The final chapter is devoted to telephone troubles and the methods of finding and remedying them; it also offers a set of regulations for the guidance and government of employees.

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WE beg to advise our readers that we have discontinued selling numbers of the SCIENTIFIC AMERICAN SUPPLEMENT dated earlier than January 1, 1914. We removed the first week in April to the Woolworth Building, New York city, and the change in our offices precluded the carrying of issues of the SUPPLEMENT extending over a period of nearly forty years. It was, therefore, necessary to turn over this portion of the business to someone who has space for carrying so large a stock. The H. W. Wilson Company of 39 Mamaroneck Avenue, White Plains, N. Y., have been chosen to take care of our back number business. They have the complete stock and are ready to supply any of the back numbers at the standard price of 10 cents. We, therefore, request that, in future, all orders for SUPPLEMENTS be sent direct to the H. W. Wilson Company instead of ourselves. Please do not order SUPPLEMENTS on letters ordering subscriptions for the SCIENTIFIC AMERICAN or the SCIENTIFIC AMERICAN SUPPLEMENT or books, or containing any other matters.

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